ENGINEERING

An Illustrated Weekly Journal

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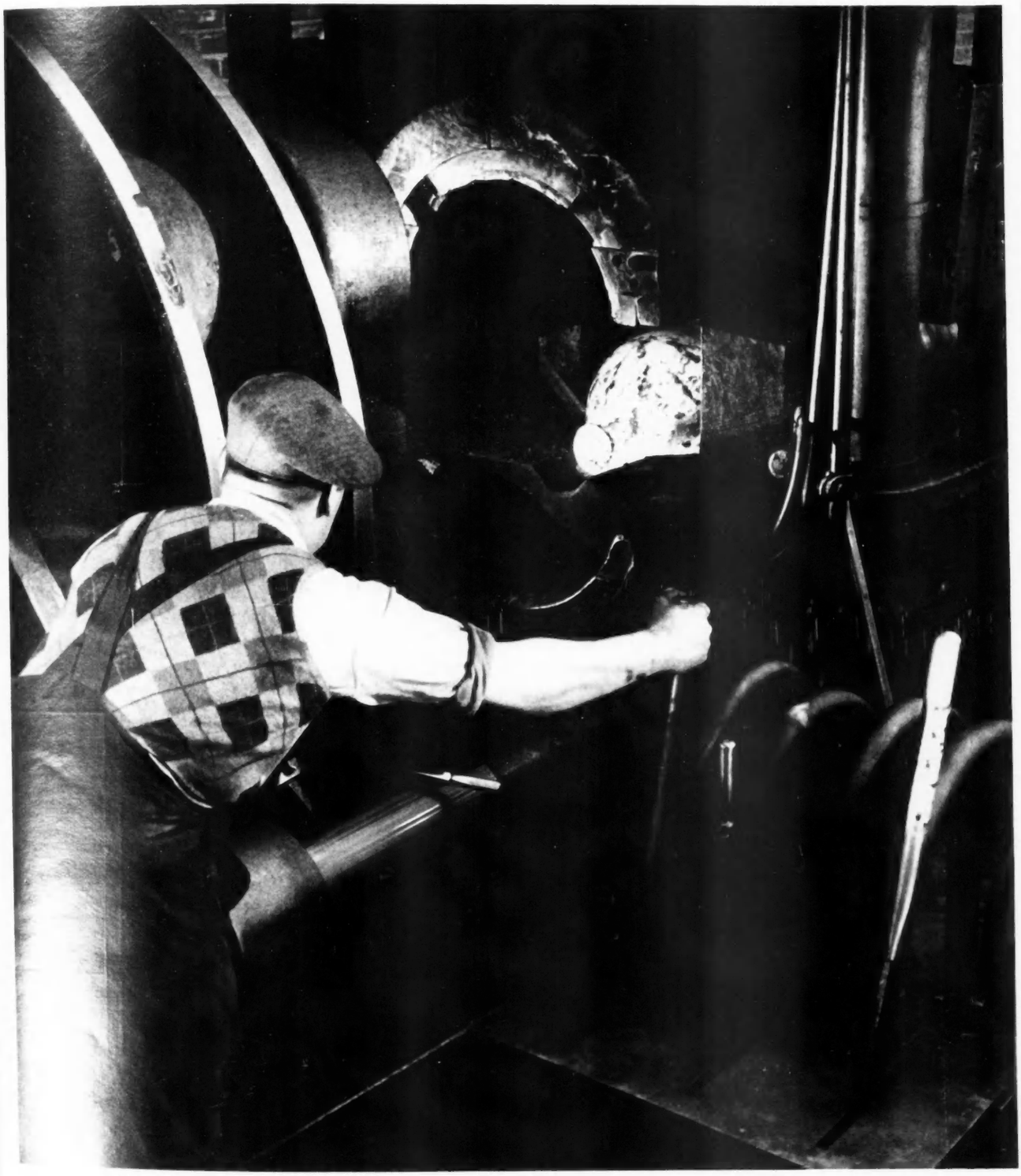

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The ideal damper control

THE NEW
LOCKHEED ELECTRO-HYDRAULIC

The system is particularly intended for use in power stations and utilizes the ideal combination: *Electricity* for simple pilot action from control-room or board (too remote for the use, economically, of hydraulic piping) away from dirt and corrosive fumes and *rugged hydraulic* cabinet on the firing floor for the operating forces.

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Outstanding advantages

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3. Manual hydraulic stand-by instantly available at will.
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5. Coupling of points at will, giving operation in or out of synchronism or separately.
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7. The automatic opening or closing of selected dampers in the event of current failure (I.D. and F.D. fans, etc.)
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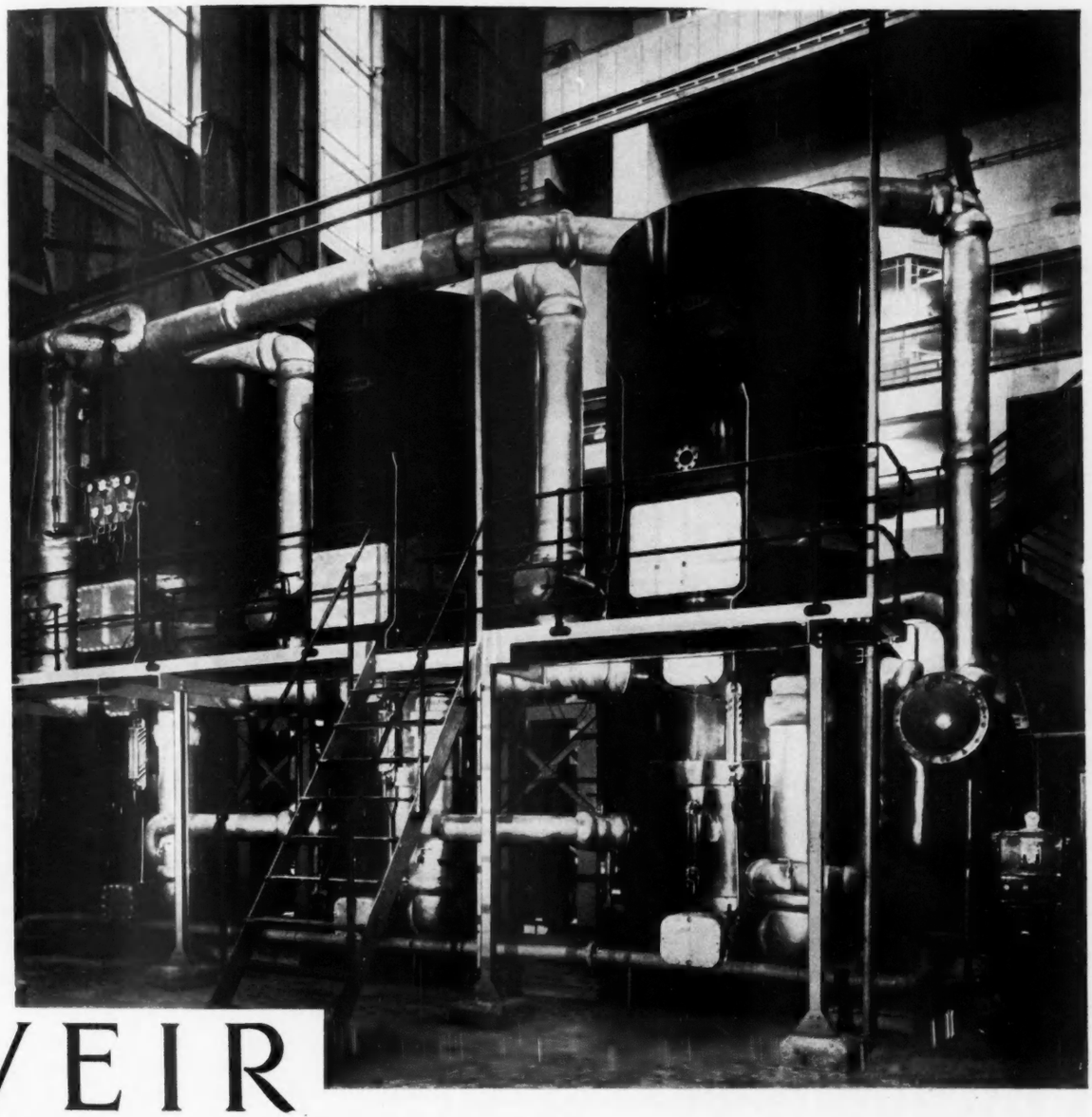

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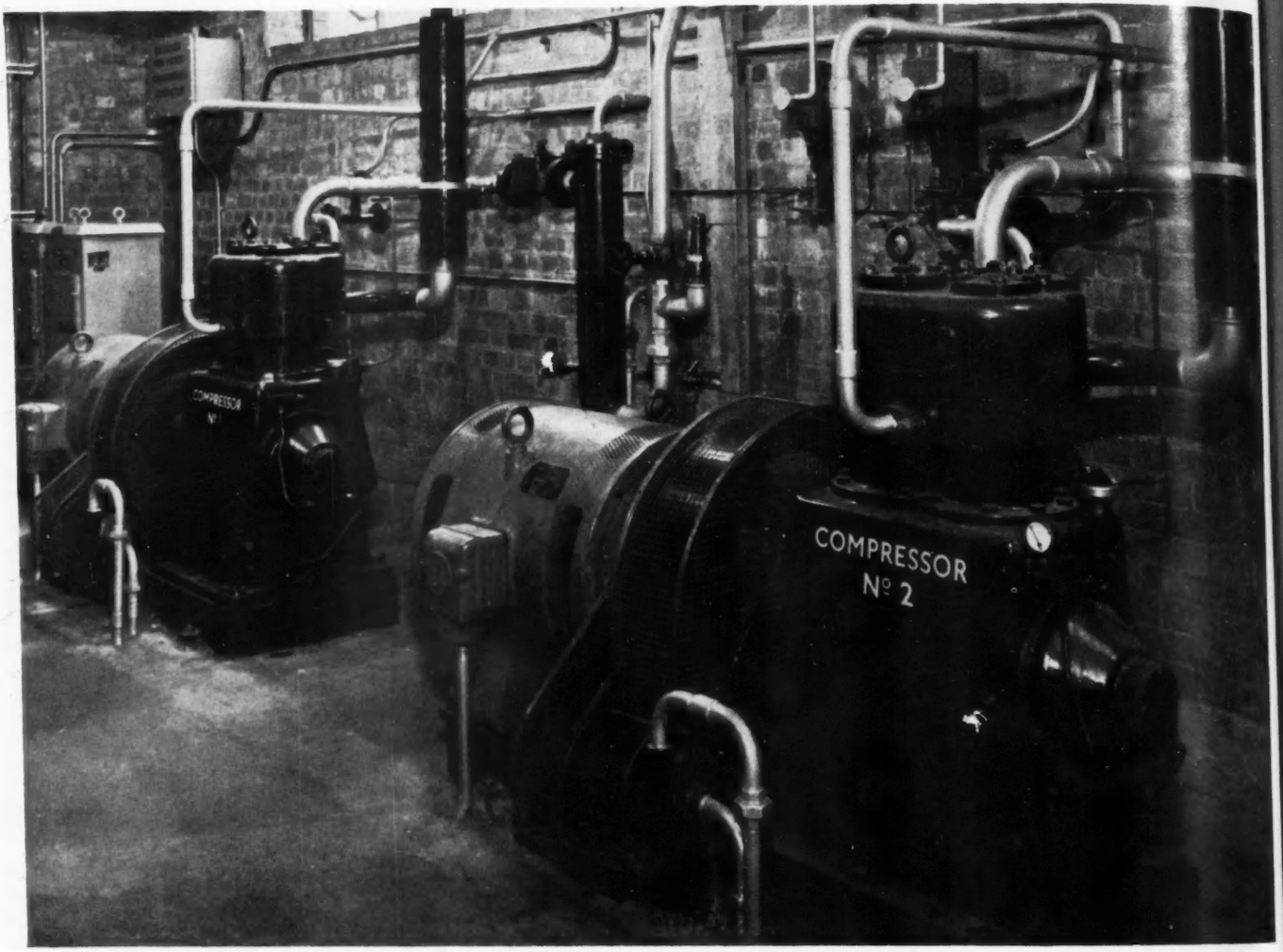

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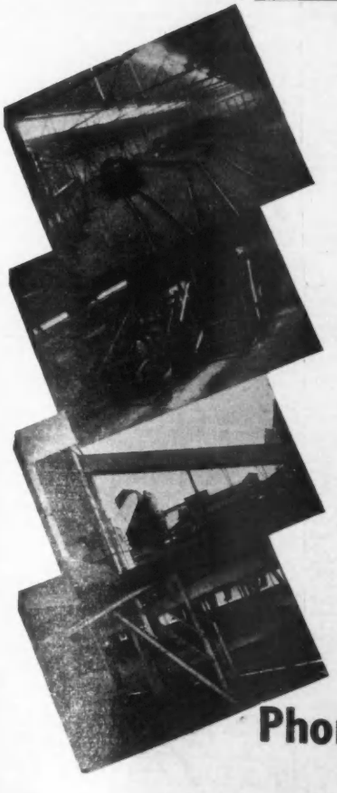

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CLASSIFIED ADVERTISEMENTS SECTION.

For all advertisements classified under the headings of Tenders, Appointments Open, Situations Wanted, Patent Agents, Partnerships, Wanted, &c., Auction Sales, Publications For Sale, Miscellaneous and Public Notices, &c., the charge will be 12s. for the first four lines or under and 3s. per line up to one inch. When an advertisement measures an inch or more, the charge will be at the rate of 36s. per inch. 5% allowed on 6, 10% on 13, 15% on 26 and 20% on 52 Weekly insertions. If use is made of a box number the extra charge is 2s. per insertion with the exception of advertisements appearing under Situations Wanted. Prospectuses and Notices of Company Meetings £25 per column. Copy instructions must be in our hands first post Monday for the following Friday's issue. Address to the Manager, ENGINEERING LTD., 35 and 36, Bedford St., Strand, W.C.2. Inclusion of advertisements must be dependent on space being available.

PUBLIC NOTICE.

LIVERPOOL REGIONAL HOSPITAL BOARD

NOTICE TO ALL ENGINEERING CONTRACTORS.

It is the Board's intention to adopt a system of selective Tendering for engineering contracts throughout the Liverpool Regional Hospital Board area which includes Merseyside, Southport, Ormskirk, St. Helens, Warrington, Wirral, Chester and West Cheshire.

The arrangements will apply to the following classes of work:—

General mechanical engineering,
General electrical engineering, and
Steam boiler plant, ancillaries and instruments,

but do not include such specialised items as kitchen, laundry and sterilising equipment, refrigerators or lifts.

The works are to be divided into the following groups:—

Group 1 : £50,000 to £100,000.
" 2 : £25,000 to £50,000.
" 3 : £10,000 to £25,000.
" 4 : £3000 to £10,000.
" 5 : £250 to £3000.

Contractors placed in Groups 4 and 5 will also be classified geographically.

Special arrangements will be made in each case for contracts exceeding £100,000 in value.

Engineering contractors are invited to submit their names to me for consideration for inclusion in the Board's approved lists. Applicants should state clearly the class (or classes) of work *and* the group (or groups) in which they would wish to submit Tenders and should also give brief details of contracts recently carried out, indicating the size and cost thereof.

Applications should reach me at the address given below by 10 a.m. on 31st May, 1956.

VINCENT COLLINGE,
SECRETARY TO THE BOARD.

19, JAMES STREET,
LIVERPOOL, 2. L 482

EDUCATIONAL.

FREE. Brochure giving details of courses in Mechanical and Production Engineering, Draughtsmanship, etc., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other Professional examinations. E.M.I. INSTITUTES, DEPT. EG. 30, LONDON, W.4. (ASSOCIATED WITH H.M.V.) G 619

LECTURES.

THE COLLEGE OF AERONAUTICS.

A Course of Lectures on

AERODYNAMIC PRINCIPLES OF THE HELICOPTER,

will be given at the College from Monday, 28th May, to Friday, 1st June, 1956.

The course will deal with the basic aerodynamics and performance of rotating wing aircraft including discussions on problems of stability and control.

FEES for the course are:

Tuition Fee ... ... £15 15s. 0d.
Residence Charge ... ... £6 10s. 0d.
(including full board)

A copy of the syllabus and Forms of Enrolment can be obtained from THE WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. L 21

EXPERIMENTAL WORK.

RESEARCH ENGINEERS LIMITED,

Northampton Grove, Canonbury, London, N.1. Canonbury 4244/5/6. We have over 25 years' experience of experimental work and prototypes. We design, develop and manufacture special purpose and labour saving machines, all at the above address. Our range is from the smallest scientific instruments to 3- or 4-ton machines. After a prototype machine has been made and found satisfactory we can manufacture as many as are required. G 656

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ENGINEERING AGENTS wide experience and excellent connections, are prepared to follow up quotation in the South Wales area.—BOX G 551, Offices of ENGINEERING.

TENDERS.

THE HIGH COMMISSIONER FOR INDIA invites **TENDERS** for the supply of:—

	QUANTITY FT.
PIPE AND TUBE ROUND OF VARIOUS SIZES TO IR-W3 ... TUBE ROUND AND SQUARE OF VARIOUS SIZES OF DIN. 1629 TO ST. 45.29 AND TO ST. 35.29	45,380 59,700

Forms of Tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, on or after 11th May, 1956, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made to " High Commissioner for India." Tenders are to be delivered by 2 p.m. Friday, 8th June, 1956.

Please quote reference No. 452/55/RLY. L 483

ROLLING STOCK AND EQUIPMENT AGAINST GLOBAL PROCUREMENT PROGRAMME No. GPs—1956-57.

THE MINISTRY OF RAILWAYS (RAILWAY BOARD), GOVERNMENT OF INDIA, propose to obtain from established and reliable manufacturers rolling stock and other Railway equipment shown in the list below. Manufacturers in Europe, United Kingdom and North America can obtain copies of the Indian Railways Global Procurement Programme of Rolling Stock No. GPs—1956-57 giving the particulars of items required and explaining the procedure for submission of quotations, from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, at a cost of 3s. per copy quoting the reference S.1168/55/CB/RLY. Manufacturers in other countries and authorised agents in India of all foreign manufacturers can obtain such copies from the Chief Design Engineer, Central Standards Office, Baroda House Annexe, New Delhi, at a cost of rupees two per copy.

LIST OF ROLLING STOCK AND RAILWAY EQUIPMENT.

WAGONS.

BROAD GAUGE :
355 Nos. Petrol Tank Wagons " TPR."
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30 Nos. Bitumen Tank Wagons " TBT."
38 Nos. Liquid Caustic Soda Tank Wagons " TCS."
3 Nos. Sulphuric Acid Tank Wagons " TSA."

COACHING UNDERFRAMES.

BROAD GAUGE :
50 Nos. Bogies Coaching Underframe 2in. Camber WA-16.
200 Nos. Bogie Coaching Underframe 2 in. Camber WA-15.

ELECTRIC MULTIPLE UNIT COACHES :
BROAD GAUGE :
90 Nos. E.M.U. Coaches 1500 Volts D.C. for Bombay Area.
203 Nos. E.M.U. Coaches 3000 Volts D.C. for Calcutta Area.

LOCOMOTIVES.

55 Nos. Electric Locomotives 3000 Volts D.C. for Calcutta Electrification.

TOWER WAGONS.

BROAD GAUGE :
9 Nos. Tower Wagons Self-propelled Diesel powered.

CRANES.

BROAD GAUGE :
12 Nos. Steam Travelling Crane, 5 ton capacity with 35 ft. long jib.

H. D. SINGH,
DIRECTOR, RAILWAY EQUIPMENT,
RAILWAY BOARD. L 545

THE HIGH COMMISSIONER FOR INDIA invites **TENDERS** for the supply of:—

	QUANTITY. NOS.
SKF SELF ALIGNING SPHERIAL ROLLER BEARINGS NO. 22326 K/C 3 R, each with one withdrawal sleeve No. A.H. 2326 suitable for journal diameter of 120 m/m Type 22326 K/C 3 R	1400

Forms of Tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, on or after 11th May, 1956, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to " High Commissioner for India." Tenders are to be delivered by 2 p.m. Friday, 8th June, 1956.

Please quote reference No. 465/55/RLY. L 499

THE HIGH COMMISSIONER FOR INDIA invites **TENDERS** for the supply of:

	TONNAGE. CWTS.
MAGNET IRON FLAT, 1 IN. BY 0.172 IN., BRIGHT FINISH—TOLERANCE ± 0.010 IN., WIDTH ± 0.002 IN. THICKNESS IN RANDOM LENGTH	367
MAGNET IRON STRIP, 15 S.W.G. THICK BY 1¼ IN. WIDE, BRIGHT FINISH IN RANDOM LENGTH —TOLERANCE ± 0.002 IN. ...	111

Forms of Tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, on or after 11th May, 1956, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to " High Commissioner for India." Tenders are to be delivered by 2 p.m. Friday, 8th June, 1956.

Please quote reference No. 410/55/RLY. L 484

CITY OF NOTTINGHAM.

WATER DEPARTMENT.

PIPE-LAYING CONTRACTS— BINGHAM SCHEME NO. 3. CONTRACTS " C," " D," " E " AND " F."

TENDERS are invited from experienced contractors for the laying and jointing of approximately 3¾ miles of 9 in., 6 in., 4 in. and 3 in. class " C " spun cast iron pipes and other appurtenant work most of which is within the Bingham Rural District, Nottinghamshire.

Specification, Forms of Tender, etc., together with the necessary drawings may be obtained from Mr. B. W. Davies, Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, on payment of a deposit of Seven Guineas which will be returned on receipt of a *bona fide* Tender not afterwards withdrawn, and the return of all documents and drawings.

Sealed tenders endorsed **" TENDERS FOR MAIN LAYING "** to be delivered to me at my office not later than Noon on Monday, 18th June, 1956.

The Corporation do not bind themselves to accept the lowest or any Tender.

T. J. OWEN,
TOWN CLERK.

Guildhall,
Nottingham. L 547

PUBLIC APPOINTMENTS.

AIR MINISTRY Works Designs Branch requires (A) in LONDON.

(1) DESIGNER/DRAUGHTSMEN (Order No. 1005) for bulk petroleum storage and pumping installations experienced in one or more of the following:—

(a) Storage tank layout and design, (b) pump house and plant layout, (c) development of pipe line schemes, (d) hydraulic calculations. Technical training to O.N.C. standard required. Salaries up to £761 p.a.

(2) STRUCTURAL ENGINEERING DESIGNER/DRAUGHTSMEN (Order No. 1001) for reinforced concrete or structural steel work with sound technical training and several years varied experience in design/detailing of:—

(a) Reinforced concrete construction for all types of buildings, or (b) steel framed sheds, warehouses and similar buildings, and

CIVIL ENGINEERING DESIGNER/ DRAUGHTSMEN (Order No. 1002) experienced in one or more of the following branches of engineering:—

(a) Earthworks and Stormwater Drainage, (b) Foul Drainage and small disposal works, (c) Water Pumping Treatment and Distribution. Salaries up to £898 p.a.

(B) IN LONDON AND PROVINCES (with liability for overseas service)

ELECTRICAL ENGINEERING DRAUGHTSMEN (Order No. 1004) experience in preparation of schemes for illumination and electrical equipment of buildings or in electrical distribution H.V. and M.V. Technical training to O.N.C. standard or equivalent an advantage. Salaries up to £898 p.a. Starting pay dependent upon age, quals. and experience. Paid overtime. Long term possibilities with pensionable and promotion prospects. Four weeks' leave a year. Normally natural born British subjects. Write, stating age, quals., employment details incl. type of work done to any Employment Exchange quoting Borough and relevant Order No. G 657

STRUCTURAL ENGINEER urgently required. Senior Assistant experienced in design of steelwork for buildings. Must be A.M.I.Struct.E., or equivalent. Salary, APT. VI, £880-£1080.

Alternate Saturdays free. Canteen facilities.

Application forms may be obtained from the COUNTY ARCHITECT, BISHOPGARTH, WESTFIELD ROAD, WAKEFIELD, and should be returned not later than the first post on May 31st, 1956. L 442

THE UNIVERSITY OF MANCHESTER.

OSBORNE REYNOLDS RESEARCH FELLOWSHIP IN ENGINEERING.

Applications are invited for the above Fellowship, of the value of not more than £600 for one year with a possible extension for a maximum of one further year. Candidates should have had experience of research in hydraulics and should be capable of independent work. Preference will be given to candidates who would be interested to work on bed movement in hydraulic models under the general direction of the Beyer Professor of Engineering, but consideration will be given to candidates who suggest other related projects. The person appointed, if suitably qualified, would be eligible for admission as a candidate for the degree of Ph.D. Further particulars and forms of application may be obtained from the REGISTRAR, THE UNIVERSITY, MANCHESTER, 13, to whom applications should be sent not later than June 2nd, 1956. L 400

KENT COUNTY COUNCIL require

SENIOR HEATING ENGINEER with good experience in the design of installations for all types of buildings. Salary within scale £880 to £1080. Applicants must be Corporate Members of the Institution of Heating and Ventilating Engineers.—Application forms from COUNTY ARCHITECT, SPRINGFIELD, MAIDSTONE. Closing date, 11th June, 1956. L 359

THE BRITISH HYDROMECHANICS RESEARCH ASSOCIATION is building up a school of experts in fluid mechanics who are to be capable of applying academic knowledge, supplemented by research, to a wide range of industrial problems.

The work is interesting and varied, covering flow problems in the process industries, chemical plant, power station and civil engineering structures, etc.; the scientific investigation of rotodynamic machines, cavitation, the hydraulic transport of coal, high pressure hydraulic machinery, automatic controls, and the physics of sliding surfaces in seals and glands.

A few well paid vacancies (£600 to £1000) are available for **YOUNG HONOURS GRADUATES IN ENGINEERING, PHYSICS OR MATHEMATICS** who can take the initiative in applying scientific fluid mechanics to industrial problems, and who preferably have some facility in the lucid exposition of their work. The work of the staff brings them in close contact with both industry and the Universities and opportunities arise from time to time for transfer to senior positions with the Association's member companies. There are also some vacancies for good research assistants with laboratory experience.

Successful applicants will be eligible to rent new houses or flats in Harlow.

Send full details to DIRECTOR OF RESEARCH, BRITISH HYDROMECHANICS RESEARCH ASSOCIATION, HARLOW, ESSEX. G 612

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

has a vacancy for a

LABORATORY MANAGER

in the Reactor Division, to be responsible for co-ordinating the requirements of Scientific staff and arranging the necessary engineering effort both internally and through outside contracts.

Applicants must have served a recognised engineering apprenticeship, or have had equivalent training, and be corporate members of a senior professional Institution, or have exempting qualifications.

Broad experience in both electrical and mechanical engineering is desirable with emphasis on practical experience, especially in the erection and commissioning of experimental plant engineering.

SALARY: The post will be graded as Engineer II: £1130-£1435.

Contributory pension scheme; five-day week, excellent working conditions and generous leave allowances.

Married officers living outside the Establishment's transport area will be eligible for housing under Authority arrangements or, alternatively, substantial assistance towards legal expenses incurred in house purchase will be available.

Send POSTCARD for application form which must be returned by 25th May, 1956, to ESTABLISHMENT OFFICER, A.E.R.E., HARWELL, DIDCOT, BERKS, quoting reference 550/26. L 522

CITY COUNCIL OF SINGAPORE.
WATER DEPARTMENT.

Applications are invited for Appointment of a temporary

RESIDENT ENGINEER (New Peirce Dam). Applicants must be Corporate Members of the Inst. C.E., must have extensive experience in the construction of earth dams on soft foundations and should have experience in sheet piling, coffer-dams, de-watering, flood diversion by tunnelling or channelling, heavy and deep excavation formation and compaction of clay and rock fill embankments, construction of heavy reinforced and mass concrete overflow, bottom outlet and intake structures, grouting of rock foundations and investigation by boring, and the consolidation of earth fill.

Static inclusive salary $2250 per month ($3150 per annum) and free quarters with hard furnishings. The appointment is on a 3 years' contract. 28 days' full pay leave per annum on satisfactory completion of contract, plus 10 days' local leave per annum. Free return 1st Class air passages for officer, wife and family subject to certain limits. Salary at half rate for the period of direct flight out to Singapore and on the return direct flight to the United Kingdom.

Further details from the COUNCIL'S LONDON AGENTS, MESSRS. ALLEN & WILLIAMS, 1, VICTORIA STREET, WESTMINSTER, LONDON, S.W.1. Closing date for full applications in DUPLICATE, Tuesday, 29th May, 1956. L 521

MINISTRY OF SUPPLY requires

PROFESSIONAL ENGINEERS AND ENGINEERING TECHNICIANS in Renfrewshire, Somerset, Lancashire and Carmarthenshire to design, develop, install and maintain systems of instrumentation and automatic and remote control gear for process plant in explosives filling factories. Qualifications: Detailed knowledge of appropriate techniques advantageous. Recognised engineering apprenticeship and A.M.I.Mech.E. or E.E. or exempting qualifications, or H.N.C. Vacancies in three grades at salaries ranging up to £1400 p.a. according to age, qualifications and experience.—Application forms from M.L. & N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26 KING STREET, LONDON, S.W.1, quoting C353/6A. L 520

CITY OF BATH EDUCATION COMMITTEE.

CITY OF BATH TECHNICAL COLLEGE.
Principal: A. H. YATES, B.Sc., B.Sc. (Eng.), A.F.R.Ae.S.

DEPARTMENT OF ENGINEERING AND SCIENCE.

Applications are invited for an appointment as **ASSISTANT (GRADE B)** to teach:
Electrical subjects to Higher National Certificate standard; experience in Electronics or Telecommunications will be a recommendation, or alternatively
Mechanical Engineering subjects to Ordinary National Certificate and Final City and Guilds Machine Shop Engineering standard.
Further particulars and form of application obtainable from the PRINCIPAL, LOWER BOROUGH WALLS, BATH.
H. W. BRAND,
DIRECTOR OF EDUCATION.
GUILDHALL, BATH. L 555

COUNTY BOROUGH OF SMETHWICK EDUCATION COMMITTEE.

SMETHWICK HALL SECONDARY MODERN SCHOOL FOR BOYS.
Head Master: Mr. F. KITSON, B.A.

METALWORK TEACHER required in September, to take charge of one of the metalwork shops. Applicants should have either a Teachers Certificate or a Full Technological Certificate or a Higher National Certificate or City and Guilds Handicrafts Certificate.
Present salary scales are £450 to £725 with prospect of very greatly improved salary scales in October. Allowance for industrial and service experience in fixing commencing salary.
Application forms may be obtained from the CHIEF EDUCATION OFFICER, 215, HIGH STREET, SMETHWICK, STAFFS., and should be returned as soon as possible.
E. L. TWYCROSS,
Town Clerk. L 554

ESSEX.

SOUTH-WEST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART, FOREST ROAD, WALTHAMSTOW, E.17.

Required in September,
ASSISTANT, GRADE "B," TO TEACH ELECTRICAL ENGINEERING subjects to Higher National Certificate Standard. Applicants should possess a Degree or equivalent qualification and have had some industrial experience.
Salary £525 by £25 to £820 plus London Allowance and additions for degree or equivalent qualification and training. Increments allowed for teaching, war/national service and approved industrial experience.
Applications (no forms) giving full particulars of qualifications to be sent to the Clerk to the Governors at the College. L 550

MECHANICAL ENGINEERS AND PHYSICISTS required by N.C.B.'s Mining Research Establishment (London Area) for research work of National importance to increase coal production. Mining problems studied include fundamentals of methods of extracting coal from seams, strata support, conveying coal to the pit bottom, and environmental conditions. Basic research and instrumentation are involved. Much of the work is carried out initially in the laboratory, but underground trials may be involved later.
Appointments (superannuable) as Scientist, grade 1 (£1365-£1750), 2 (£991-£1390) or 3 (£617-£1124), within inclusive scales according to qualifications and experience. Excellent career prospects. Good hons. deg. in physics or mechanical engineering (or equiv.) required. Applicants nearing completion of a post-graduate research programme or reading for finals will be considered.
Write, with full particulars of age, education, qualifications to NATIONAL COAL BOARD, MINING RESEARCH ESTABLISHMENT, WORTON HALL, ISLEWORTH, MIDDLESEX, marking envelope SS/274. L 551

TECHNICIANS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE.

POST "A" (Ref. 871/26). To assist in development of airborne electrical and electronic equipment to meet production and service requirements. To arrange the issue of drawings and information to contractors and inspectorates and to deal with queries in early stages of manufacture. Applicants should have served a recognised apprenticeship in electrical or electronic engineering or have had equivalent Training in appropriate trade. They must have had experience in getting equipment from design stages into small quantity manufacture and be acquainted with up-to-date manufacturing techniques. Experience with electrical or electronic equipment for use in missiles would be an advantage. Candidates should have H.N.C. or equivalent in electrical or mechanical engineering.

POST "B" (Ref. A874/26). To assist engineers in the development of airborne electrical and electronic equipment to meet production and service requirements. Applicants should have served a recognised apprenticeship in electrical or mechanical engineering. Possession of O.N.C. or equivalent qualifications in electrical or mechanical engineering is desirable. Applicants should have experience in, the handling of difficulties associated with the early stages of small quantity manufacture. Experience with electrical or electronic equipment for use in missiles would be an advantage, and candidates will be expected to be acquainted with up-to-date manufacturing techniques.

SALARY: Post "A," £873-£1080 per annum.
Post "B," £608-£748 per annum.

Contributory Superannuation Scheme. Successful married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates; alternatively assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to SENIOR RECRUITMENT OFFICER at the above address not later than 15th May, 1956, quoting the appropriate reference number. L 514

CHAPMAN & HALL

Ready this Month

PRACTICAL SOLUTION OF TORSIONAL VIBRATION PROBLEMS

With Examples from Marine, Electrical, Aeronautical and Automobile Engineering Practice

by

W. Ker Wilson
D.Sc., Ph.D., Wh.Ex., M.I. Mech. E.

Volume 1—Frequency Calculations

Third Edition—Revised

Size: 9" × 5¼" *736 pages* *Illustrated* *105s. net.*

For long recognised as a standard text and reference work, this new edition has been entirely rewritten. In recent years the study of torsional vibration has gained considerably from improvements of instrumentation and experimental procedures which have led to a better understanding of the more complex aspects of the subject. Due account of this has been taken in preparing the new edition and the work is now completely up to date.

THE DISPOSAL OF SEWAGE

A Textbook for the Use of Engineers, Sanitary Inspectors and Students

by

T. H. P. Veal
B.Sc., A.M.I.C.E.

Third Edition—Revised

Size: 8¼" × 5¼" *220 pages* *Illustrated* *30s. net.*

The appearance of the third edition of this book is proof of its value to those desirous of acquiring a knowledge of the main principles and methods of sewage treatment and disposal. In addition to a general revision of the text, a new chapter dealing with the disposal of liquid waste has been included.

MODERN PHYSICS

A Textbook for Engineers

by

R. L. Sproull
(Associate Professor of Physics, Cornell University)

Size: 9¼" × 6" *411 pages* *Illustrated* *62s. net.*

The aim of this work is to present to engineers those parts of twentieth-century physics which are of greatest importance in engineering. It describes the modern physics of electrons, atoms and nuclei, and applies this basic physics to problems of engineering interest.

37 ESSEX STREET, LONDON, W.C.2

BRISTOL EDUCATION COMMITTEE.

THE COLLEGE OF TECHNOLOGY.
Principal: G. H. MOORE, M.Sc., F.P.S., F.R.I.C.

Applications invited for following posts:—
(*a*) **GRADE B ASSISTANT TO TEACH MECHANICAL ENGINEERING** Subjects in National Certificate and Diploma Courses.
(*b*) **GRADE B ASSISTANT TO TEACH WORKSHOP TECHNOLOGY** and City and Guilds Machine Shop Engineering subjects. Ability to assist with Production Engineering subjects an advantage.
(*c*) **GRADE A ASSISTANT TO TEACH MAINLY ELECTRICAL TRADE SUBJECTS** including electrical installation. Ability to assist with radio and communication courses an advantage.
Posts (*b*) and (*c*) are available from 1st September next; post (*a*) is an existing vacancy. Application forms, returnable within two weeks, and further particulars from REGISTRAR, COLLEGE OF TECHNOLOGY, UNITY STREET- BRISTOL, 1.
G. H. SYLVESTER,
Chief Education Officer. L 553

NOTTINGHAMSHIRE EDUCATION COMMITTEE.

BEESTON COLLEGE OF FURTHER EDUCATION,
HIGH ROAD, CHILWELL, NOTTINGHAM.
Principal: W. F. H. DALE, B.Sc., F.R.I.C.

APPLICATIONS are invited for the new appointment of
ASSISTANT LECTURER IN MECHANICAL ENGINEERING SUBJECTS, to commence 1st September, 1956, or as soon thereafter as possible. Ability to teach to the level of Ordinary National Certificate standard essential. Salary: Burnham Technical Grade A Scale: £450 by 18 to £725 per annum. Additions for approved qualifications/training and increments for approved service/experience. Please send foolscap s.a.e. to the PRINCIPAL for forms and further particulars. Closing date 21st May, 1956.
J. EDWARD MASON,
Director of Education. L 549

CENTRAL ELECTRICITY AUTHORITY.

SOUTH EASTERN DIVISION.

1. BRIGHTON "A" POWER STATION.
ASSISTANT SHIFT CHARGE ENGINEER—Class H, Grade 9, £896 10s.-£946 p.a., including shift allowance. Applicants who should preferably be educated to H.N.C. standard must have had experience in the generation of modern high pressure turbine and boiler plant, E.H.T. switchgear and in the control of labour. P.F. experience an advantage.
2. KINGSTON "B" POWER STATION.
MAINTENANCE ENGINEER (ELECTRICAL)—Class G, Grade 6, £950 5s.-£1013 5s. p.a., including London allowance. Applicants should preferably possess H.N.C. in Electrical Engineering and have had extensive experience in the maintenance of E.H.T. switchgear and motors, alternators, low voltage auxiliaries and Power Station instruments. Experience in the control of labour essential.
3. LITTLEBROOK POWER STATION.
ASSISTANT SHIFT CHARGE ENGINEER—Class L, Grade 9, £1109 15s.-£1194 p.a., including London and shift allowances. For details of duties—see vacancy No. 1.
N.J.B. Conditions of Service. Applications in writing stating qualifications, experience, positions held, etc., should be submitted, according to location of vacancy, to the STATION SUPERINTENDENT at:
1. Brighton "B" Power Station, Portslade-by-Sea, Sussex.
2. Kingston "B" Power Station, Downhall Road, Kingston-on-Thames.
3. Littlebrook Power Station, nr. Dartford, Kent.

Closing date 18th MAY. L 54

PRESTON.

HARRIS COLLEGE OF FURTHER EDUCATION.

MECHANICAL ENGINEERING DEPARTMENT.

Applications are invited for a
LECTURER IN PRODUCTION ENGINEERING.
Candidates should possess a Degree or equivalent qualification and should have had good practical experience.
Ability to teach Metrology, Machine Tools and other Production Engineering subjects to an advanced level is essential.
Present Burnham Scale for Lecturers—£965-£1065.
Forms of application may be obtained from the undersigned to whom they should be returned immediately.
H. WILKINSON, Ph.D., A.Inst.P.,
PRINCIPAL.
HARRIS COLLEGE OF FURTHER EDUCATION,
CORPORATION STREET,
PRESTON, LANCS. L 565

THE BRITISH SOCIETY FOR RESEARCH IN AGRICULTURAL ENGINEERING has vacancy for
JUNIOR ENGINEER in Instrumentation Department. Inter.B.Sc., H.N.C., or equivalent qualification essential; drawing office experience and of design of small mechanisms or in testing materials an advantage.
Salary scale: £429 at 21 to £706 with starting salary limited to £559 at 26 or over.
Application forms from SECRETARY, N.I.A.E., WREST PARK, SILSEE, BEDS. L 512

BEDFORDSHIRE EDUCATION COMMITTEE.

LUTON COMMITTEE FOR EDUCATION.

LUTON AND SOUTH BEDFORDSHIRE COLLEGE OF FURTHER EDUCATION.
Principal: W. F. STEPHENSON, B.Sc., F.R.I.C.

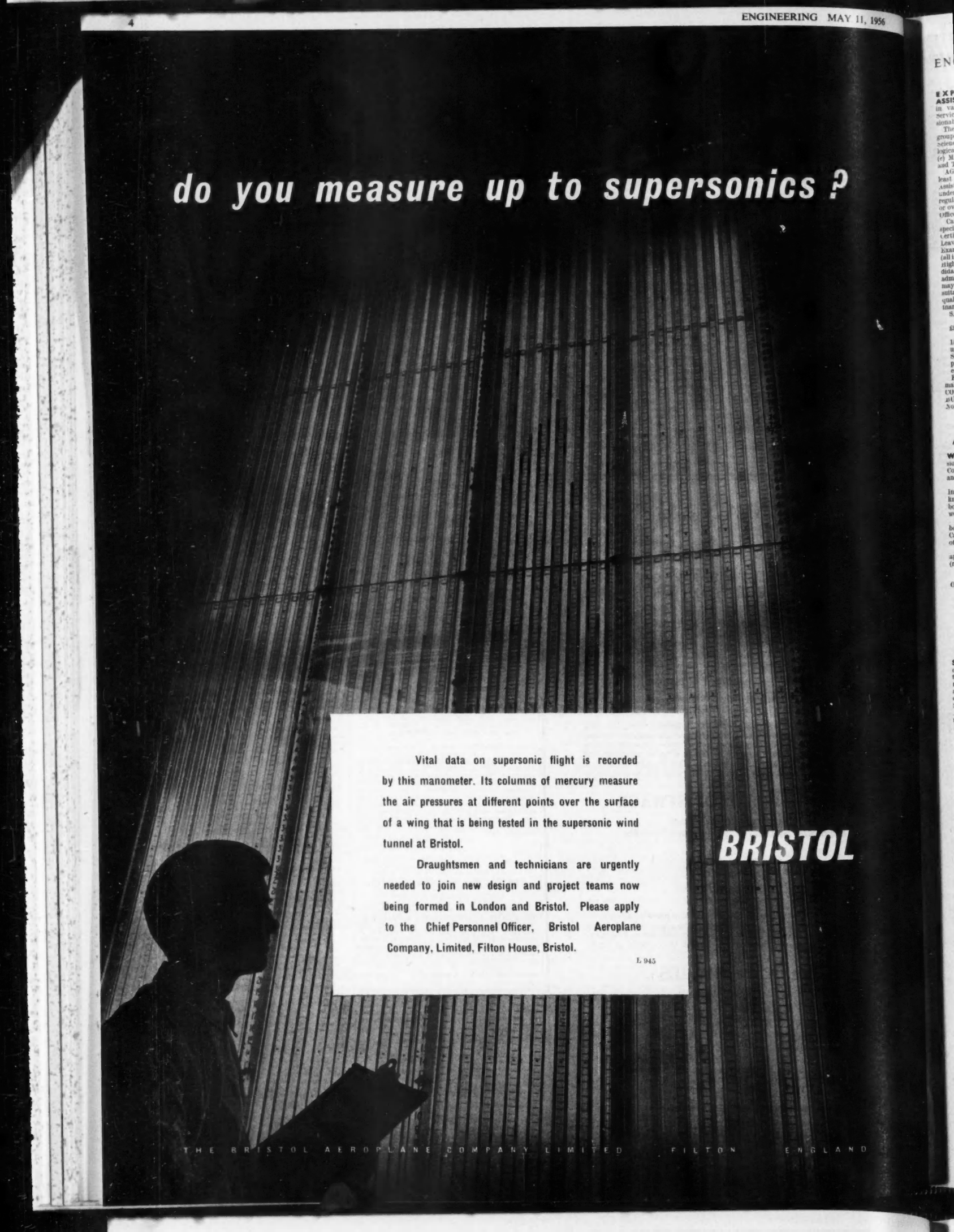
Applications are invited for the following appointments, duties to commence on 1st September, 1956:—

TWO SENIOR LECTURERS IN MECHANICAL ENGINEERING.
Applicants must be Honours Graduates in Mechanical Engineering and have Corporate Membership of the Institution of Mechanical Engineers. Teaching and industrial experience is desirable. Applicants should be prepared to teach one or more of the following subjects to B.Sc. (Eng.) Final and Higher National Certificate standard:—
Applied Thermodynamics,
Theory of Machines,
Strength of Materials,
Mechanics of Fluids.
For one of the posts, preference will be given to applicants who offer the subject of Applied Thermodynamics. Facilites for research are available.

LECTURER IN PRODUCTION ENGINEERING.
Applicants should have academic qualifications in Production Engineering and be Corporate Members of the Institution of Mechanical or Production Engineers. Good industrial experience is essential, and previous teaching experience desirable. Applicants should be prepared to teach two of the following subjects to Higher National Certificate students:—
Production Planning and Work Study,
Machine Tools and Metrology,
Jig and Tool Design,
as well as Workshop Technology and Engineering Drawing to Craft courses.
Salary in each case will be in accordance with the Burnham (Further Education) Report.
Send s.a.e. (foolscap) for further details and application form, which should be returned within ten days of the appearance of this advertisement, to J. A. CORBETT, CLERK OF THE GOVERNORS, 63/69, GUILDFORD STREET, LUTON. L 516

Classified Advertisements continued on Page 4.

do you measure up to supersonics?



Vital data on supersonic flight is recorded by this manometer. Its columns of mercury measure the air pressures at different points over the surface of a wing that is being tested in the supersonic wind tunnel at Bristol.

Draughtsmen and technicians are urgently needed to join new design and project teams now being formed in London and Bristol. Please apply to the Chief Personnel Officer, Bristol Aeroplane Company, Limited, Filton House, Bristol.

L 945

BRISTOL

THE BRISTOL AEROPLANE COMPANY LIMITED FILTON ENGLAND

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects (*a*) Mathematical and Physical sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects and (*e*) Miscellaneous (including, e.g., Geology, Library and Technical Information Services).

AGE LIMITS: For Experimental Officers, at least 26 and under 31 on 31st December, 1956; for Assistant Experimental Officers at least 18 and under 28 on 31st December, 1956. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1956 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

SALARY (London):—

Experimental Officer £838-£1008 (men); £742-£914 (women).

Assistant Experimental Officer, £342 (at age 18) to £736 (men), £664 (women). Starting pay up to £611 (men) or £567 (women) at 26 or over. Somewhat lower outside London. Promotion prospects. Women's scales being improved under equal pay scheme.

Further particulars, for which you are advised to make early application, from CIVIL SERVICE COMMISSION, SCIENTIFIC BRANCH, 30, OLD BURLINGTON STREET, LONDON, W.1, quoting No. 894-95/56. L 531

METROPOLITAN WATER BOARD.

APPOINTMENT OF WELL ENGINEER.

WELL ENGINEER required for permanent pensionable staff. Salary scale, £922-£1219 per annum. Commencing salary according to age, qualifications and experience. Age not over 45 years.

Applicants should be corporate members of the Institution of Civil Engineers and should have a knowledge of geology and experience in well and borehole sinking and in the supply of water from wells.

A house is available, if required, in a good neighbourhood, at an inclusive rental of £130 per annum. Car allowance payable for use of private car on official duties.

Particulars of the appointment and a form of application may be obtained from the undersigned (reference G.P. 10).

S. D. ASKEW,
CLERK OF THE BOARD.

OFFICES OF THE BOARD,
NEW RIVER HEAD,
ROSEBERY AVENUE, E.C.1. L 518

HERTFORDSHIRE COUNTY COUNCIL.

HATFIELD TECHNICAL COLLEGE,
ROE GREEN, HATFIELD, HERTS.
Principal: Dr. W. A. J. CHAMPAN, M.Sc. (Eng.).

SENIOR LABORATORY TECHNICIAN required in the Department of Mechanical and Production Engineering. General workshop experience necessary as well as a knowledge of the maintenance and manufacture of instruments and laboratory equipment. Duties to commence as early as possible. Salary Scale: Miscellaneous Grade V/VI, £560-£670. Applications should be made to the REGISTRAR (REF. M/P), HATFIELD TECHNICAL COLLEGE, ROE GREEN, HATFIELD, HERTS. L 517

DARLINGTON EDUCATION COMMITTEE.

COLLEGE OF FURTHER EDUCATION.
Principal: C. E. BEYNON, B.Sc., F.R.I.C., A.Inst.P.

Required in September,

SENIOR LECTURER IN MECHANICAL ENGINEERING to specialise in Heat Engines and assist with Strength of Materials or Theory of Machines; graduate and/or equivalent professional qualification essential. Salary £1065 by £25 to £1215.

Further particulars, and application forms (to be completed and returned not later than May 23) may be obtained from the EDUCATION OFFICER, NORTH LODGE, DARLINGTON.

D. PETER,
CHIEF EDUCATION OFFICER. L 563

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on 1st January, 1956, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two year's experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:—

(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological Sciences.
(iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).

Inclusive salary scale £302 (at 18) to £611 (men) or £528 (women). Starting pay up to £449 (men) or £407 (women) at 25. Women's pay subject to improvement under Equal Pay scheme. Somewhat less in provinces. Opportunities for promotion.

Further particulars, for which you are advised to make early application, from CIVIL SERVICE COMMISSION, SCIENTIFIC BRANCH, 30, OLD BURLINGTON STREET, LONDON, W.1, quoting No. 850/56. L 530

UNIVERSITY OF BIRMINGHAM.

DEPARTMENT OF CIVIL ENGINEERING.

Applications are invited for the post of **SENIOR RESEARCH ASSISTANT.** The research programme concerns the use of Electrical Analogues for the solution of problems in Fluid Mechanics and Elasticity.

Applicants should have at least a good honours degree in Physics or Engineering, some previous research experience being very desirable. The salary will be in the range £650-£850 p.a. depending on experience and qualifications. The appointment is to commence on 1st October, 1956.

Applications should be sent to PROFESSOR S. C. REDSHAW, DEPARTMENT OF CIVIL ENGINEERING, THE UNIVERSITY, EDGBASTON, BIRMINGHAM, 15, as soon as possible.

G. L. BARNES,
Secretary.

The University,
Birmingham, 15.
May, 1956. L 561

COUNTY BOROUGH OF BRIGHTON
EDUCATION COMMITTEE.

BRIGHTON TECHNICAL COLLEGE.
Principal: G. E. WATTS, M.A., Ph.D. (Cantab.), B.Sc. (Lond.), F.R.I.C.

LECTURER IN CIVIL ENGINEERING required for January 1st, 1957. Honours Graduate to teach Civil Engineering subjects to degree and professional levels with special reference to hydraulics. Previous teaching and industrial or research experience desirable. Corporate membership of the Institution of Civil Engineers would be an advantage. Present salary scale (subject to revision under any new Burnham award) £965 by 25 to £1065.

Further particulars and forms of application from the undersigned, to be returned to the College Principal as soon as possible.

W. G. STONE,
DIRECTOR OF EDUCATION.

54, OLD STEINE,
BRIGHTON. L 558

NATIONAL COAL BOARD.

NORTH EASTERN DIVISON.

Applications are invited for the vacancy of **AREA CHIEF ENGINEER** in No. 7 Area at Wakefield, Yorks.

Applicants must be suitably qualified engineers with wide technical and engineering administrative experience and have the ability to co-ordinate the work of all engineering branches. They should have held responsible senior appointments and be fully conversant with the design and operation of all types of mining plant and machinery.

Applications, stating age, qualifications and experience should be forwarded to the AREA ADMINISTRATIVE OFFICER, NATIONAL COAL BOARD, No. 7 (WAKEFIELD) AREA, P.O. BOX 13, NEWTON HILL, WAKEFIELD, to arrive not later than the 21st MAY, 1956. L 557

NORTH WEST METROPOLITAN
REGIONAL HOSPITAL BOARD.

Applications are invited from Corporate Members of the Institution of Electrical Engineers and/or Institution of Mechanical Engineers for two newly created posts of

PRINCIPAL ASSISTANT ENGINEER (SCALE II). The Board are engaged on a number of new building and engineering projects including a new hospital at Welwyn.

Duties will include design, preparation of briefs for consulting engineers and supervision of electrical section in the one case and of both mechanical and heating and ventilating sections in the other.

Salary scale: £1050 by £40 (5) by £25 to £1275 plus £50 London Weighting. Whitley Council conditions.

Apply, stating which post and giving age, qualifications (with dates) and experience with names of two referees to SECRETARY, NORTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD, 11A, PORTLAND PLACE, W.1, by 30th May, 1956. L 556

H.M. DOCKYARD TECHNICAL COLLEGES: **ASSISTANT LECTURER GRADE A.** The Civil Service Commissioners invite applications from men for 15 permanent appointments (Science) to begin as soon as possible. Candidates must have a University degree (or equivalent qualification). Qualifications in Mathematics, Physics, Chemistry or Engineering (Electrical and Mechanical) required. Burnham scales for Technical Colleges; posts pensionable under Civil Service Superannuation Acts on non-contributory basis. Details and application forms from SECRETARY, CIVIL SERVICE COMMISSION, BURLINGTON GARDENS, LONDON, W.1, quoting No. 4589/56/9. Completed forms must reach him by 31st May, 1956. L 527

UNITED KINGDOM OF LIBYA.

Applications are invited for the post of **TECHNICAL DIRECTOR,** Public Works Department, Provincial Administration of Tripolitania, United Kingdom of Libya.

The candidate, who will be expected to reorganise the Department, must be a qualified civil engineer with several years' practical experience.

Total emoluments—£2000 per annum.

Emoluments are not liable to British Income Tax (Schedule E) but will attract local tax of 8 per cent.

Appointment will be for one year in the first instance, but renewable.

Paid leave of three days for each month of resident service.

A Provident Fund exists under which both the Administration and the official are required to contribute a sum equivalent to 7½ per cent. of the official's salary: the total is paid to the official on termination of contract.

Passages by air provided for the official, his wife and up to three dependent children under eighteen years.

Applications in writing giving qualifications and experience within ten days to ROOM 139, FOREIGN OFFICE, S.W.1. L 529

THE COLLEGE OF AERONAUTICS.

Vacancies exist for

ENGINEERS/DEMONSTRATORS in the DEPARTMENT OF AIRCRAFT PROPULSION to work on all forms of aircraft and guided weapon power plants or their components. These include rockets, ramjets, gas turbines, piston engines and associated subjects such as combustion, heat transfer, and mechanical testing. Much of the work involves operation of full scale engines. Those appointed will be responsible, under the direction of lecturers, for preparation and supervision of students' experimental work in the field in which they are experienced. They will assist in research work and opportunities for extending experience will be provided. Salary, according to qualifications and experience, on a scale rising to £850 p.a. with superannuation under F.S.S.U., and family allowance. House may be available. Applications giving full particulars of qualifications and experience and containing the names of three referees, to THE RECORDER, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS., from whom further details may be obtained. L 533

MECHANICAL ENGINEERS required at MINISTRY OF SUPPLY Establishment, near Sevenoaks, Kent, for research and development in connection with Guided Weapons. 1st or 2nd class honours degree or equivalent qualification considered for **SCIENTIFIC OFFICER,** lower qualifications, e.g. pass degree, H.N.C., etc., with minimum of Higher School Certificate (Science) or equivalent, for **EXPERIMENTAL OFFICER.** Salaries according to age, experience, etc., in ranges: Senior Scientific officer (min. age 26) £1095-£1250; Scientific Officer (min. age 21) £514-£933 (superannuable); Experimental Officer (min. age 26) £781-£968; Assistant E.O. £328 (age 18)-£706. At least 3 years post graduate research experience required for S.S.O. grade.—Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C357/6A, closing date 4th June, 1956. L 532

CITY OF NOTTINGHAM.

WATER DEPARTMENT.

CIVIL ENGINEERING ASSISTANT.

Applications for this permanent, pensionable appointment are invited from Engineering Graduates, and should be sent to the Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, by the 31st May next, with the names of two persons to whom reference may be made. Salary in accordance with Grade A.P.T. II of the National Scale, viz., £595 by £20 to £675, or, in the case of Graduates who have had at least five years' satisfactory experience, £690 by £30 to £840.

T. J. OWEN,
TOWN CLERK.

GUILDHALL,
NOTTINGHAM. L 526

DERBYSHIRE EDUCATION COMMITTEE.

CHESTERFIELD COLLEGE OF TECHNOLOGY.
Principal: E. CARDWELL, M.Sc. (Lond.), Wh.Ex., M.I.Mech.E.

Applications are invited for the full-time post of **ASSISTANT GRADE "B"** in the Department of Mechanical and Civil Engineering with effect from the 1st September, 1956. Duties will include teaching mechanical engineering subjects to H.N.C. level. Ability to teach mathematics to A.1 standard an advantage.

Salary will be in accordance with the Burnham Technical Scale for Assistants Grade B, with allowances for teaching and approved industrial experience. Further particulars and forms of application from the undersigned (stamped addressed foolscap envelope required), to whom applications should be returned by 17th May, 1956.

S. A. BROADWELL,
REGISTRAR.

COLLEGE OF TECHNOLOGY,
INFIRMARY ROAD,
CHESTERFIELD. L 509

CENTRAL ELECTRICITY AUTHORITY, HEADQUARTERS, S.E.1, require a **TRANSLATOR/ABSTRACTOR.** Candidates should have knowledge of engineering subjects with ability to translate accurately and speedily from at least two foreign languages. Salary £819-£895 p.a. Applications stating age, present position, previous experience and salary to D. MOFFAT, DIRECTOR OF ESTABLISHMENTS, WINSLEY STREET, W.1, not later than 25th May, 1956. Quote ref. AE/809. L 479

ENGINEER (MAIN GRADE)

required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS, to take control of a small workshop engaged in the assembly inspection and testing of a variety of electronic and electro-mechanical equipments. Applicants should have served a recognised engineering apprenticeship and be corporate members of the I.E.E. or have exempting qualifications.

Experience in the use of testing equipment involving panclimatic cycling and an up to date knowledge of circuits and methods of manufacture of a wide variety of electronic and electro-mechanical instruments are essential. Candidates should also possess a knowledge of test gear design and have had experience in controlling both industrial and non-industrial staff.

SALARY: £1130-£1435 p.a.

Contributory Superannuation Scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates, alternatively assistance towards legal expenses incurred in house purchase may be available.

Requests for application forms by POSTCARD to the SENIOR RECRUITMENT OFFICER at the above address not later than 19th May.

Quote reference 1137/26. L 477

Classified Advertisements continued on Page 6

FUNDAMENTALS OF VIBRATION ANALYSIS

N. O. MYKLESTAD *Head of Stress, Vibration and Gear Group, AiResearch Manufacturing Company of Arizona*

A concise introduction to vibration analysis, designed for undergraduate or graduate courses. The subject matter is so arranged that the reader will not only learn to solve vibration problems, but will gain a clear picture of the phenomenon itself. The book provides a new treatment of vibration instruments, balancing, the orthogonality condition and damped modes of free vibration. The many examples make it especially useful for practising engineers.

9 × 5 inches 250 pages 49s.

MECHANICAL VIBRATIONS fourth edition

J. P. DEN HARTOG *Professor of Mechanical Engineering, Massachusetts Institute of Technology*

The fourth edition of this text for students of mechanics and mechanical engineering has been considerably revised and enlarged. The first half is intended mainly for undergraduates; the second part is more advanced and will be of value to practising engineers and to those doing postgraduate work.

New material has been added on Karman vortices and on non-linear vibrations, with recent examples. Many fresh problems have been included.

9 × 6 inches 475 pages approx. 67s. 6d.

McGraw-Hill *available shortly from your bookseller*

NATIONAL COAL BOARD.

WEST MIDLANDS DIVISION.

Applications are invited for the post of **AREA CHIEF ENGINEER** in the Cannock Chase Area of the West Midlands Division.

The post covers the complete co-ordination of all engineering services within the area, Mechanical, Electrical and Civil and extensive reconstruction programmes and heavy plant installations are involved. Organisational ability is essential.

Salary will be not less than £1750 per annum.

Applications with experience to date to be addressed to the DIVISIONAL ESTABLISHMENT OFFICER, NATIONAL COAL BOARD, HIMLEY HALL, DUDLEY, WORCS, by 18th May, 1956. L 490

LIVERPOOL REGIONAL HOSPITAL BOARD.

HEATING AND VENTILATING ENGINEERING ASSISTANT required for permanent pensionable appointment in the Regional Engineer's Department.

Applicants should have the Ordinary National Certificate in Heating and Ventilating subjects or an examination of equivalent standard, be experienced in the design, survey and estimating of schemes. Experience in heating and domestic hot and cold water supplies is necessary. It is also desirable that applicants shall be able to take particulars on site, complete working drawings from rough sketches and provide estimates for complete engineering schemes.

Salary scale £480 to £670. Commencing salary dependent on age and experience.

Applications stating age, qualifications, experience, present and previous appointments, together with names and addresses of three referees (two technical) to me at 19, JAMES STREET, LIVERPOOL, 2, by 18th May, 1956.

VINCENT COLLINGE,
SECRETARY TO THE BOARD. L 480

TECHNICIAN

required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS, to be responsible for the control of skilled mechanics engaged on the inspection, maintenance and repair of electrical, mechanical and electronic instruments and electronic test gear. Applicants should have served a recognised electrical engineering apprenticeship and have some years' experience in the trade on instrumentation and/or electronic equipment. Some knowledge of monitoring equipment associated with radio-active materials would be an advantage. O.N.C. or equivalent qualification is desirable.

SALARY: £743 (at age 30 or over)—£873 per annum.

Contributory Superannuation scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates or, alternatively assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to the SENIOR RECRUITMENT OFFICER at above address not later than 15th May, 1956.

Quote reference 1046/26. L 475

SOMERSET EDUCATION COMMITTEE.

WESTON-SUPER-MARE TECHNICAL AND ART INSTITUTE.—Required in September, **INSTRUCTOR OF ENGINEERING WORKSHOP SUBJECTS,** to prepare students for City and Guilds examinations in Machine Shop Engineering. Applicants should have good technical qualifications and industrial experience in Engineering. Some teaching experience an advantage. Salary £450 by £15 to £725. Approved industrial experience recognised for increments. Further particulars and application forms from the PRINCIPAL.

W. J. DEACON,
CHIEF EDUCATION OFFICER.
COUNTY EDUCATION OFFICE,
TRULL ROAD,
TAUNTON. L 473

APPOINTMENTS OPEN.

An old-established manufacturer of rubber, plastic and mechanical textile products wishes to select **A YOUNG MAN WITH FIRST CLASS HONOURS DEGREE IN ENGINEERING OR SCIENCE,** for training in Commercial and Executive duties. The successful applicant will become Assistant to Commercial Manager of one factory of the Group, situated in Lune Valley district of Lancashire, this position bringing him into contact with a wide variety of Management functions including financial budgeting, production planning, purchasing, costing, estimating, all related to manufactured products of great technical interest which will continually make calls upon his scientific background knowledge. This appointment will be made with prospects of promotion to greater responsibility in view and represents an unusual opportunity for an Engineer or Scientists with a first-class brain and personality to transfer to Management. A superannuation scheme is in operation and assistance will be given with housing if necessary.—Full details of qualifications, experience and present position to BOX L 535, Offices of ENGINEERING.

JUNIOR ENGINEER. MAY & BAKER, LTD., DAGENHAM, ESSEX, require in their Plastics Production Division, a mechanical engineering graduate, aged 22-25, to assist in the development of new products and eventually to assume control of their manufacture. Contributory Pension Scheme; five-day week.—Apply initially in writing, quoting reference No. 122, to the PERSONNEL OFFICER. L 537

ENGINEERING ESTIMATOR required for new constructional and major modification work with a large heavy chemical company in East London. Similar work with a manufacturing or contracting company preferred. Technical education to H.N.C. level. Minimum age 28, permanent, progressive post.—WRITE BOX ZN.127, DEACON'S ADVERTISING, 36, LEADENHALL STREET, LONDON, E.C.3. L 560

CHIEF ENGINEER required by McKECHNIE BROTHERS, LTD., for their Chemical and Copper Smelting Works at Widnes, Lancs. Age 35 to 40. Salary up to £2000 per annum for well qualified and experienced man.—Write, giving full particulars, to P.O. BOX 4, WIDNES, LANCS. L 538

ARTIFICIAL LIMB AND APPLIANCE CENTRE, EDINBURGH.

Applications are invited from persons qualified in Engineering or allied subjects for post of **TECHNICAL OFFICER.** Duties will include the inspection and advising on repairs and maintenance of motor cars, tricycles and invalid chairs; ability to discuss problems and submit reports is essential. Salary scale £525 by 20 (2) by 25 (3) by 15 (1) to £655 per annum. Superannuation Scheme. Applications, in writing, giving age, qualifications and experience, together with names of two referees to SECRETARY, ASTLEY AINSLIE, EDENHALL AND ASSOCIATED HOSPITALS BOARD OF MANAGEMENT, GRANGE LOAN, EDINBURGH, by 16th May. L 543

GOSS PRINTING PRESS COMPANY, LIMITED, have an immediate vacancy for:

JIG AND TOOL DRAUGHTSMAN.

Applicants should have served a recognised engineering apprenticeship and have Drawing Office experience in light and medium precision engineering; should hold National Certificate. Permanent position with generous superannuation scheme, bonus is paid annually. Salary in accordance with experience and ability.—Please supply full details of age, experience and qualifications to PERSONNEL MANAGER, GREENBANK STREET, PRESTON. L 500

IMPERIAL CHEMICAL INDUSTRIES LIMITED,
Metals Division.
Vacancies exist for

MECHANICAL, CIVIL AND ELECTRONIC DRAUGHTSMEN

with H.N.C. or equivalent for work in connection with Guided Weapons Project. Permanent posts available with good starting salaries; first class working conditions, including profit sharing scheme.

Applications to G. S. M., I.C.I. METALS DIVISION, SUMMERFIELD RESEARCH STATION, KIDDERMINSTER. L 497

BRITISH PETROLEUM COMPANY, LIMITED, has a vacancy for an **ELECTRONIC ENGINEER** for work in the Instrument Group at its Research Station at Sunbury-on-Thames. Applications are invited from men with a University Degree in Physics or Electrical Engineering or equivalent. Some experience in the design and development of electronic instruments preferable. Work will include development of instruments for the control and testing of internal combustion engines, for process control, and for chemical and physical measurements. Age under 35. National Service obligations must have been fulfilled. Good Pension Scheme. Salary according to age, qualifications and experience.—Write giving full details, quoting H.3303(a), to BOX 8869, c/o 191, GRESHAM HOUSE, E.C.2. L 494

PUMPS AND TURBINES MAINTENANCE ENGINEER urgently required by Major Oil Company for service in MIDDLE EAST oilfields, age under 45 years. Applicants should be Mechanical Engineers of graduate standard and have had extensive experience in a supervisory capacity in operating, maintaining and installing all kinds of pumps and turbines. Previous oilfield experience desirable. Two years' tour in first instance and salary not less than £2650 p.a. payable also while on leave. Married accommodation and free family passages available.—Write, giving age, brief details of career, etc., and asking for application form to BOX EG.192, c/o 191, GRESHAM HOUSE, E.C.2. L 495

INSTALLATION ENGINEER required to take complete charge of site erection of steel works plant abroad and in the U.K. by the Davy-United Group of Companies, the largest builders in Britain of Rolling Mills and other heavy plant for the Steel Industry. First class experience of installation and maintenance of rolling mill and auxiliary plant essential, and candidates must be prepared to travel extensively. This important and responsible post carries a suitable salary and participation in Staff Pension Scheme.—Applications stating full particulars to PERSONNEL DEPARTMENT, DAVY AND UNITED ENGINEERING COMPANY, LIMITED, PARK IRON WORKS, SHEFFIELD, 4. L 488

ENGINEER to take charge of experimental group in industrial Research and Development department in the Midlands. This is a job for a well-qualified man with administrative as well as technical interests. —Write giving full details of age, qualifications and experience.—PERSONNEL MANAGER, BOX L 492, Offices of ENGINEERING.

BUYER (MALE), 30-35 years, to act as Deputy to Chief Buyer, required by progressive Rayon Yarn production Company. Good general education, industrial buying and engineering experience essential Pension scheme, five-day week, canteen, good salary and prospects for suitable applicant.

Applicants, which will be treated confidentially, should state age, qualifications, experience and present salary and be addressed to PERSONNEL MANAGER, BRITISH ENKA, LTD., AINTREE, LIVERPOOL. L 481

CIVIL ENGINEER required for construction work on Great Ouse Flood Protection Scheme in Norfolk. Salary including allowances from £800 p.a. upwards, according to age and experience.

Apply SIR M. MACDONALD & PARTNERS, 72, VICTORIA STREET, LONDON, S.W.1. L 486

TO COPE WITH RAPIDLY EXPANDING HOME AND EXPORT DRIVE,

CROFTS (ENGINEERS) LIMITED, THORNBURY, BRADFORD, YORKS,

URGENTLY REQUIRE

DRAUGHTSMEN

Salary, bonus and prospects are excellent for men with necessary experience and qualifications.

Applicants should have good general Engineering experience. Knowledge of Gear Units, Clutches and Transmission Equipment an advantage. Educated preferably to Higher National standard.

The positions are permanent and superannuated.

Applications to be made in writing to PERSONNEL MANAGER and endorsed D.O.3.

Travelling expenses for interviews will be refunded and all matters relating to the applications will be regarded as strictly confidential. L 270

PLANT DRAUGHTSMAN.

BRYANT & MAY, LTD., require a Plant Draughtsman for their London factory.

Applicants should have served a Drawing Office and Workshop apprenticeship with Technical education up to H.N.C. standard. They should be about 35 years of age, but a younger or older man would be considered.

The successful candidate would be expected to work on all types of power and manufacturing plant with direct responsibility to the Works Engineer.

Commencing salary above present A.E.S.D. London rate depending on qualificational and experience. Pension, Co-Partnership and other welfare benefits available. New entrants are required to pass a medical examination.

Applications should be addressed to PERSONNEL MANAGER (WORKS), BRYANT & MAY, LTD., FAIRFIELD WORKS, BOW, LONDON, E.3, quoting No. 107. L 508

SECTION LEADER, experienced, required by Consulting Engineers in South London, to take charge of Plant Layout and Piping Department of large drawing office. Minimum age 30, good prospects, salary not less than £1000 p.a. Pension Scheme. Luncheon Vouchers, five-day week.—BOX L 478, Offices of ENGINEERING.

ESTIMATING ENGINEERS

required by

HUMPHREYS & GLASGOW, LTD.,

Must have experience in estimating for general or chemical engineering projects.

Permanent and superannuated post carrying a good salary. Five-day week. Holiday arrangements respected.

Apply in writing to:

HUMPHREYS & GLASGOW, LTD.,
22, Carlisle Place,
London, S.W.1.

L 505

PHILIPS ELECTRICAL LTD. Arc Welding Department wish to appoint a **SALES SUPERVISOR.** Candidate should be between 30-40 years of age with a good basic education to degree or H.N.C. standard, preferably in science or engineering. An applicant without technical education will be considered if he has had relevant experience in production or mechanical engineering. The Sales Supervisor will be required to organise and lead an established team of technical representatives covering the whole of the United Kingdom and, therefore, emphasis will be placed upon qualities of personality and leadership in filling the post.—Applications should be addressed to PERSONNEL OFFICER, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2, quoting reference No. 818. L 474

DEVELOPMENT ENGINEER AND PHYSICISTS are required for work in the new and rapidly expanding laboratories of Louis Newmark Ltd. at New Addington, Surrey. The work includes the design and development of instruments and equipment for the aircraft and allied industries, and some working experience of small electromagnetic instruments is desirable. Good salary based on age and experience. Pension Scheme.—Apply in writing giving full particulars to: PERSONNEL OFFICER, LOUIS NEWMARK, LTD., PREFECT WORKS, PURLEY WAY, CROYDON. L 546

ASSISTANT DEVELOPMENT ENGINEER required by important Company within easy reach of Leicester. Higher National Certificate in Mechanical Engineering essential and applicants should have had Works and Drawing Office experience. Age 23-26.—Applications marked Private and Confidential should be addressed in first instance to the Personnel Manager, BOX L 562, Offices of ENGINEERING.

DRAUGHTSMAN—age about 30—National Certificate standard, general mechanical engineering and some electrical experience, including factory plant layout and services, structural knowledge an advantage. Also Junior Draughtsman—age 22/25 years—of good education with some experience of general mechanical engineering. Five-day week. Contributory Pension Scheme.—Write, giving details of experience and stating salary required, to THE NESTLE COMPANY, LIMITED, HAYES, MIDDLESEX, quoting reference CGC/VS. L 567

WILTON ICI WORKS

ENGINEERING DESIGNERS

The construction of the Company's factory at Wilton on a 2000-acre site has proceeded continuously since 1946 and now over ten million pounds are spent each year on new works. Staff with experience in design of modern works are required for this development.

The immediate vacancies are in the Design Office for :—

ASSISTANT TECHNICAL OFFICERS
MECHANICAL ELECTRICAL
CIVIL STRUCTURAL
INSTRUMENT

The appointments are to permanent staff and the Company is anxious to engage men who have had first rate experience to assist with the long-term plans for further development. Candidates in this category will be invited to interview, without commitment, at the Company's expense.

SALARIES
Commencing salaries up to £900 per annum will depend on the age and experience of candidates. The salaries of men engaged will be reviewed annually.

TERMS OF EMPLOYMENT
Five-day, 39-hour working week, Pension Fund, Profit Sharing Scheme, etc.

HOUSING
After joining the staff married men will receive a reasonable refund of removal (including travel) expenses, and to assist them in house purchase, facilities are available in approved cases for substantial loans; in addition, legal charges will be advanced.

Assistance is given in the procuring of rented houses, flats or lodgings.

Wilton is situated at the foot of the Cleveland Hills in Yorkshire, five miles from the coast. Working conditions are good and recreation facilities, including golf, tennis and badminton, are available.

Write for application form to: Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting advertisement reference ICI/X/302/e. L 541

Leading manufacturers of container closures in the Midlands have a numbes of vacancies for ambitious **DESIGN DRAUGHTSMEN** preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation. Write in confidence with details of experience, positions held, salary required, to P.A. METAL CLOSURES LIMITED, BROMFORD LANE, WEST BROMWICH. G 627

WANTED

DRAUGHTSMEN to design in aluminium for sales development. Must possess Higher National Certificate in Mechanical Engineering. Location Banbury. Good working conditions and pleasant surroundings. Attractive starting salaries offered up to £800 p.a. with prospects of promotion from drawing board. Pension plan in operation. Send brief details of qualifications and experience to NORTHERN ALUMINIUM CO., LTD., BUSH HOUSE, ALDWYCH, LONDON, W.C.2. G 562

A CHIEF METHODS ENGINEER,

aged 35-45, is required by an old-established medium/heavy engineering company in South Lancashire. The position is of Senior Executive status and calls for a first class technical and practical engineering background. An engineering degree or membership of a suitable professional institution will be an advantage but not a necessity.

Duties include control of jig and tool design, planning, ratefixing, toolroom and tool stores, with a total staff of 80. A comprehensive pension and insurance scheme is in operation.—Applicants should give fullest details of education, previous experience, age and salary required to BOX L 411, Offices of ENGINEERING.

DESIGNER DRAUGHTSMEN required for interesting development work in alloy steelworks producing a variety of semi-finished products. Machine tool or light mechanical experience preferred. Superannuation scheme, good canteen facilities and modern Drawing Office. Applicants to give age, full details of technical training and experience, and salary required.

Apply LABOUR MANAGER, SAMUEL FOX AND CO., LTD., STOCKSBRIDGE WORKS, NR. SHEFFIELD. L 413

MECHANICAL ENGINEERING DESIGNER-DRAUGHTSMAN required, preferably with experience in Steelworks Hot Mills and Plant design. Modern drawing office, pension scheme and canteen facilities. Replies to state age, technical training and experience with salary required.

Apply LABOUR MANAGER, SAMUEL FOX AND CO., LTD., STOCKSBRIDGE WORKS, NR. SHEFFIELD. L 414

JOSEPH BOOTH & BROS., RODLEY, LEEDS, have vacancies for the following personnel in their Drawing Office:

WELDING ENGINEER to check welding design and supervise and develop welding technique generally; Plant Draughtsman with structural building experience.

ELECTRICAL DRAUGHTSMAN for the layout and ordering of crane electrical equipment and preparation of wiring diagrams;

Five-day week; superannuation scheme; canteen; Apply in writing to the CHIEF DRAUGHTSMAN, stating age, experience and salary required. L 468

DESIGN DRAUGHTSMAN required by leading AUSTRALIAN Manufacturer of VALVES. A thorough experience in the design of valves up to 36 in. bore size, for water works, pumping stations and water reticulation, etc., is essential. Assistance with migration cost and housing. Commencing salary, £1300 Aust. Superannuation benefits after two years' service.—Write, stating age, experience and qualifications to THE SECRETARY, HATTERSLEY (ORMSKIRK), LIMITED, ORMSKIRK, LANCASHIRE. L 410

CIVIL ENGINEERING, STRUCTURAL STEELWORK AND REINFORCED CONCRETE DESIGNER required for major development programme. Applicants must be capable of designing all types of structures and heavy plant foundations. Modern drawing office and canteen facilities. Full details of age, technical training and experience and salary required.

Apply LABOUR MANAGER, SAMUEL FOX AND CO., LTD., STOCKSBRIDGE WORKS, NR. SHEFFIELD. L 412

CHIEF DRAUGHTSMAN for expanding Light Engineering Company.—Apply, giving full details of training, experience, qualifications and salary required, to W. E. & F. DOBSON, LTD., CHELSEA STREET, NOTTINGHAM. L 428

ASSISTANT CIVIL ENGINEER required for large integrated Iron and Steel Works. The appointment is initially for duties in connection with a two years' plant extension programme, with permanency on demonstration of ability.

Applicants should preferably be between 25 and 35 years of age and have completed their National Service. They should have had at least three years' practical Civil Engineering experience and be competent in the use of surveying instruments.

Applications, giving full details of education, training and experience, should be addressed to: THE CHIEF ENGINEER, APPLEBY-FRODINGHAM STEEL COMPANY, SCUNTHORPE, LINCS. L 435

MANAGER required for Civil Engineering Department in a large industrial undertaking. Applicants must have wide experience and first class technical qualifications.—Apply to BOX L 572, Offices of ENGINEERING.

WILTON ICI WORKS

ELECTRICAL, MECHANICAL AND INSTRUMENTATION ENGINEERS

For engineers direct from the University, or for trained Mechanical Engineers with industrial experience, the chemical industry provides opportunities for a satisfying and well paid career. At Wilton during the last ten years many plants of great technical interest have been erected and plans made for further continuous development over a number of years. Here there are vacancies for Engineers on design, construction, and operation, with opportunities for training and advancement to managerial positions.

The chance to take part in this enterprise should particularly attract men graduating in 1956. Starting salaries are good and, should it be necessary, there are opportunities of gaining practical experience in a course which will initiate men into industry and be acceptable to the chartered engineering institutions.

This modern factory is situated at the foot of the Cleveland Hills within easy reach of the Yorkshire Coast. Working conditions are excellent and recreational facilities including golf, tennis and squash are available. After joining the staff, married men will receive a reasonable refund of removal (including travel) expenses; to assist in house purchase, facilities are available in approved cases for loans; in addition, legal charges may be advanced.

The appointments are permanent and include membership of the Staff Pension Fund and participation in the Employees Profit Sharing Scheme.

Any Engineering Graduate who is interested in a career which will combine interesting and productive work with prospects of steady progress should write to: STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES, LIMITED, WILTON WORKS, MIDDLESBROUGH, YORKSHIRE, quoting advertisement reference ICI/X/303/f. L 540

SENIOR MECHANICAL ENGINEERING ASSISTANT required by London Consulting Engineers. Drawing Office experience also knowledge of marine and/or mechanical engineering essential. Knowledge of dock and harbour plant an advantage.—Write stating age, training and experience to BOX L 304, Offices of ENGINEERING.

A large works in the North West invites applications for the appointment of

MECHANICAL ENGINEER.

Graduate engineers preferred. Age group 30-40. Salary £1500-£1800 depending on qualifications and experience. Membership of a staff pension and life assurance scheme is obligatory and an assisted house purchase scheme is in operation.

Applications with details of experience and qualifications to BOX L 312, Offices of ENGINEERING.

SENIOR DRAUGHTSMEN required by old-established firm of hydraulic engineers in Cheshire, preferably with design experience in hydraulic presses, valve gear and pumps. Good salary to suitable men. Five-day week, pension scheme and canteen facilities.—Apply in confidence stating age, experience and salary required to BOX L 156, Offices of ENGINEERING.

MECHANICAL ENGINEER required to deal with Tenders and Contracts for the supply of Colliery Winders. Excellent opportunity for man with similar experience.—Apply giving full details of training and experience to PERSONNEL MANAGER, THE GENERAL ELECTRIC CO., LTD., FRASER & CHALMERS ENGINEERING WORKS, ERITH, KENT. L 419

OVERHEAD LINE CONSTRUCTION.

SUPERVISING ENGINEER.

MERZ AND MCLELLAN, Consulting Engineers, require an

ASSISTANT CONSTRUCTION ENGINEER

to supervise the building of 330-kV steel tower lines in Rhodesia. Candidates must have considerable experience of similar work at voltages of 110 kV and above, and be prepared to climb towers at all stages of construction.

Remuneration depends on age, ability and experience. Pension Scheme. Adequate provision made for cost of living and leave. Home leave after 2½ years, travel paid.

Application, with particulars of education, training, experience, single or married, age and salary required, to MERZ AND MCLELLAN, "MILBURN", ESHER, SURREY. L 417

STEELWORK DESIGNERS.

MERZ AND MCLELLAN require Steelwork Designers for their office at Newcastle-upon-Tyne: (*a*) qualified designers with not less than 5 years experience; (*b*) Junior Designers. These appointments are in connection with the range of Structural Steelwork required in connection with large coal-fired and Atomic Power Stations.—Applications, by letter in the first instance, quoting reference SAR, should be addressed to MERZ AND MCLELLAN, CARLIOL HOUSE, NEWCASTLE-UPON-TYNE, 1. L 392

STRUCTURAL ENGINEER with wide experience of the design and detailing of all types of steel structures and with administrative experience required to act as deputy to the Chief Engineer by large firm of London Consultants. The firm is expanding and the vacancy offers excellent opportunities for the right type of man.—Write in confidence giving details of previous experience and salary required to BOX No. 355, GLOVERS ADVERTISING LTD., 351, OXFORD STREET, LONDON, W.1. G 635

MECHANICAL ENGINEER required with first-class experience in diesel and/or gearing work. Sound qualifications essential, including good drawing office experience. 25 miles N.W. London. Superannuable. Commencing salary £800 per annum —Write with full details BOX A.C.18415, SAMSON CLARKS, 57-61, MORTIMER STREET, W.1. L 265

JUNIOR DRAUGHTSMEN required, O.N.C. standard, experience in general engineering and/or sheet metal fabrications for work on specialised equipment for the Dairy, Brewery and Chemical Industries. Salary commensurate with experience.—BOX L 284, Offices of ENGINEERING.

DRAUGHTSMEN (SENIOR AND JUNIOR) required for work in connection with the following branches of Coke Oven and Gasworks plants.

(*a*) Mechanical and By-Product Plant.
(*b*) Pipework.
(*c*) Steelwork for Buildings and Conveyors.

Applicants should be competent men able to work with the minimum of supervision. Technical qualifications to O.N.C. or beyond. Good remuneration and prospects for capable men. Pension scheme. Five-day week; Canteen Facilities.—State age and experience to the PERSONNEL OFFICER (D.O.), WOODALL-DUCKHAM CONSTRUCTION COMPANY LTD., WOODALL-DUCKHAM HOUSE, 63-77, BROMPTON ROAD, LONDON, S.W.3. G 550

A.E.C. LIMITED require

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Classified Advertisements continued on Page 8

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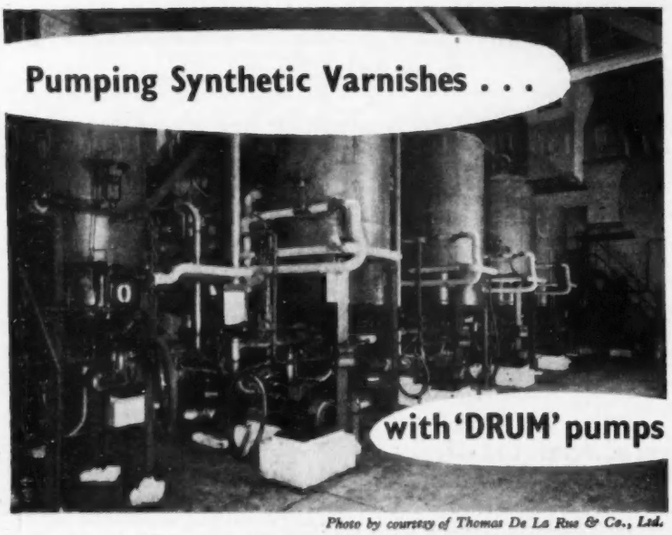

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DR 57

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DRAUGHTSMAN required for Engineering Dept. of Manufacturing concern. Age approx. 24-30. Educated to H.N.C. preferred. Experience in General Engineering, Plant Layout, Buildings, Factory Services, etc. Some electrical experience would be an advantage. Good man capable of working with minimum of supervision would find good conditions of employment, Canteen facilities, pension Scheme etc. Replies giving full details and salary required to MARTIN BLACK & CO. (WIRE ROPES) LTD., SPEEDWELL WORKS, COATBRIDGE. L 137

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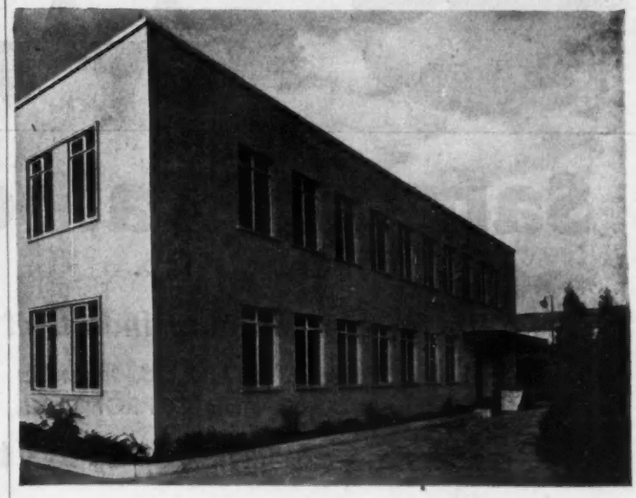

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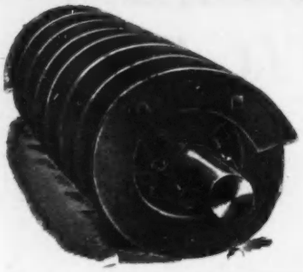

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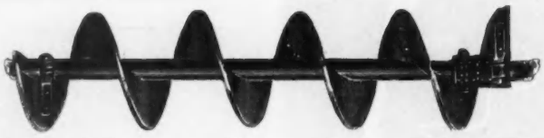

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We can handle capacities up to **20 tons**

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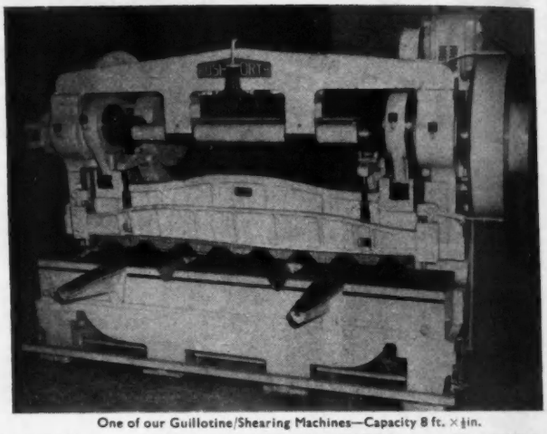

One of our Guillotine/Shearing Machines—Capacity 8 ft. × ¼in.

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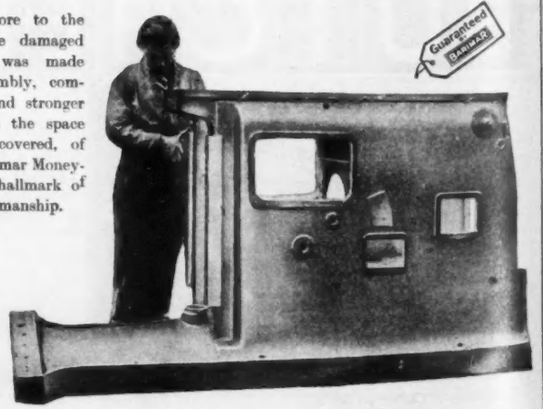

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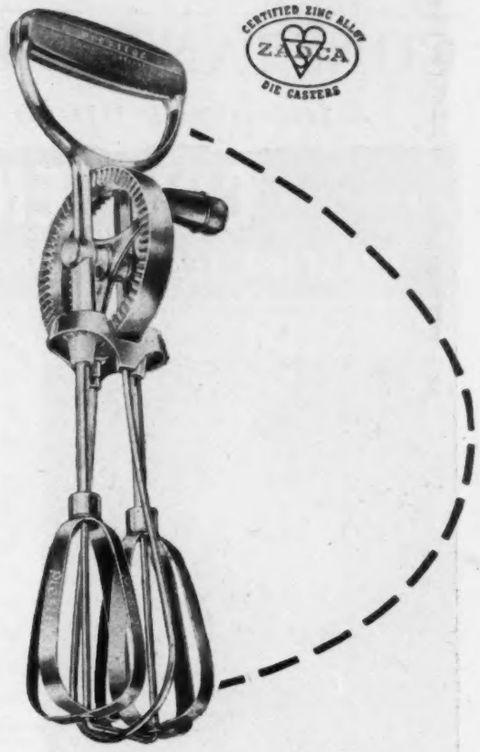

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A complete range for all duties . . .

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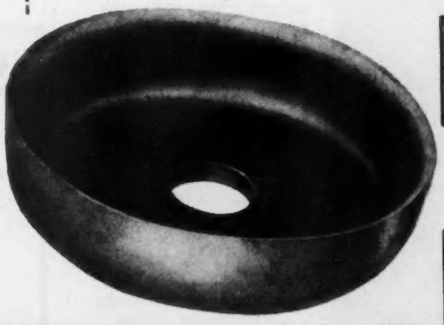

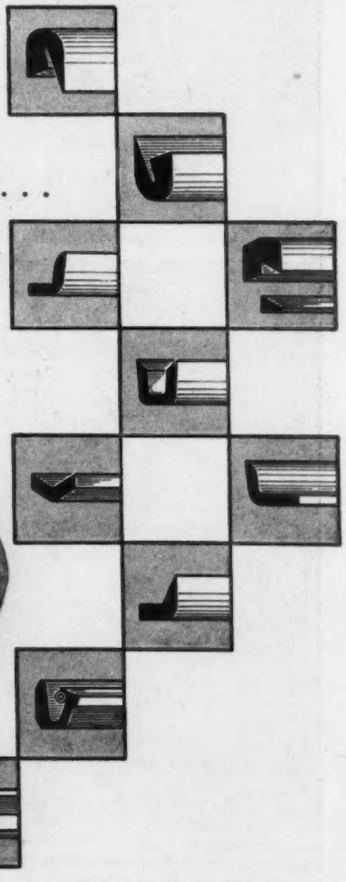

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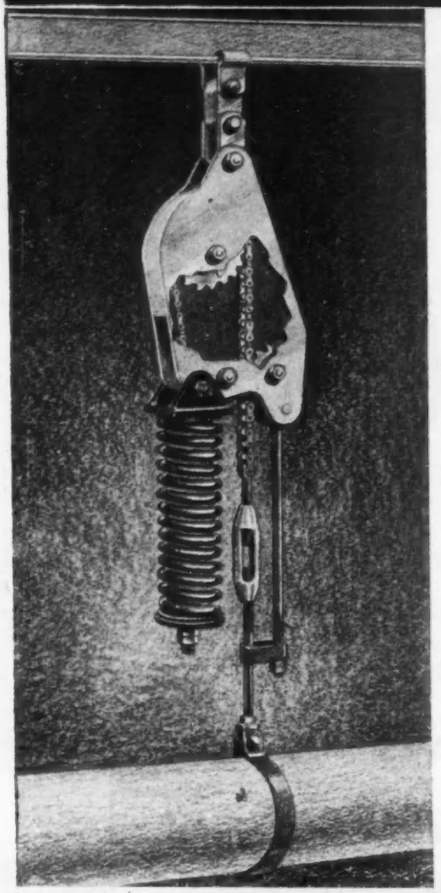
CONSTANT TENSION
—for loads up to 2 tons

CON-TEN
CONSTANT TENSION PIPE SUPPORT



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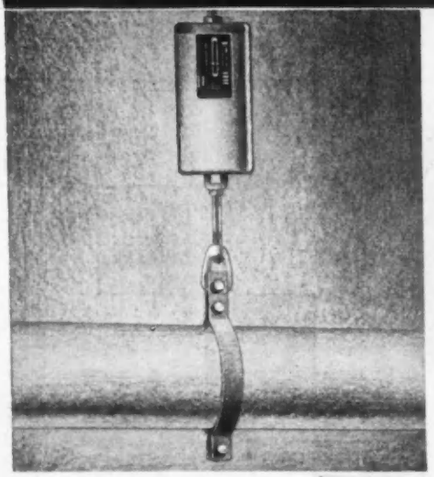
British Patent No. 474008
U.S.A. Patent No. 2129320

LEIBFRIED REDTOP PIPE SUPPORT



The Leibfried Redtop Pipe Support is not just a spring hanger, it also is a spring seat, the choice of either application being merely a matter of how the support is installed. This type of support will give pipe suspension designers far less trouble than other types in its application to the multitude of complex conditions confronting them from day to day. Redtop Pipe Supports are stocked in three standard model sizes providing for a supporting load of any value ranging from 100 to 5000 pounds and a total travel of 3 inches. Illustrated literature on request.

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M-W-55

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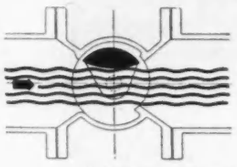
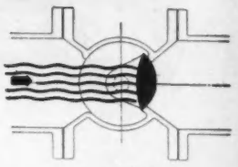


Valve open.



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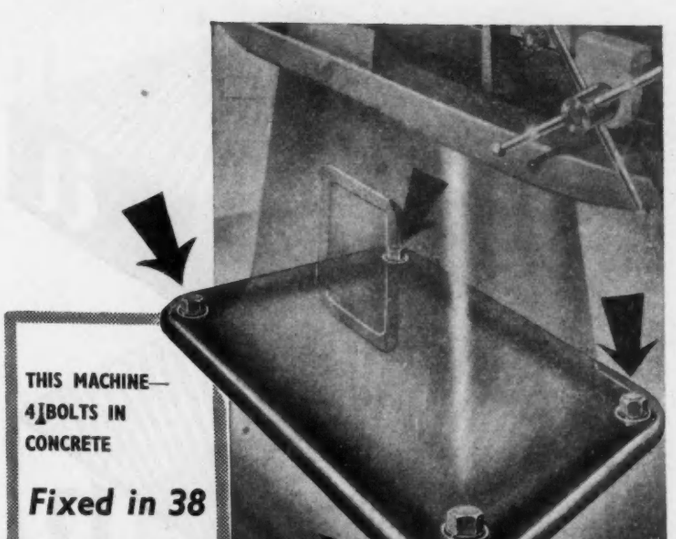

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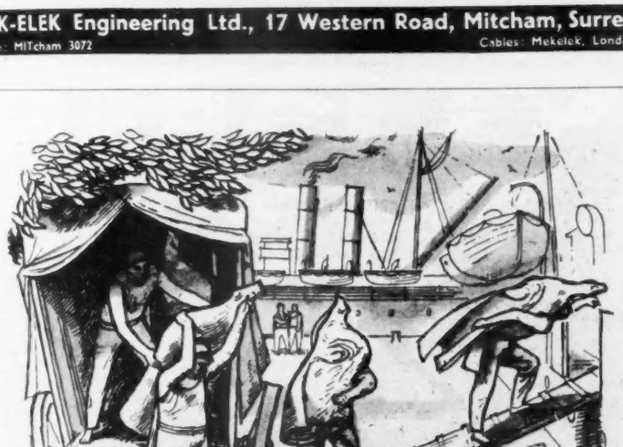

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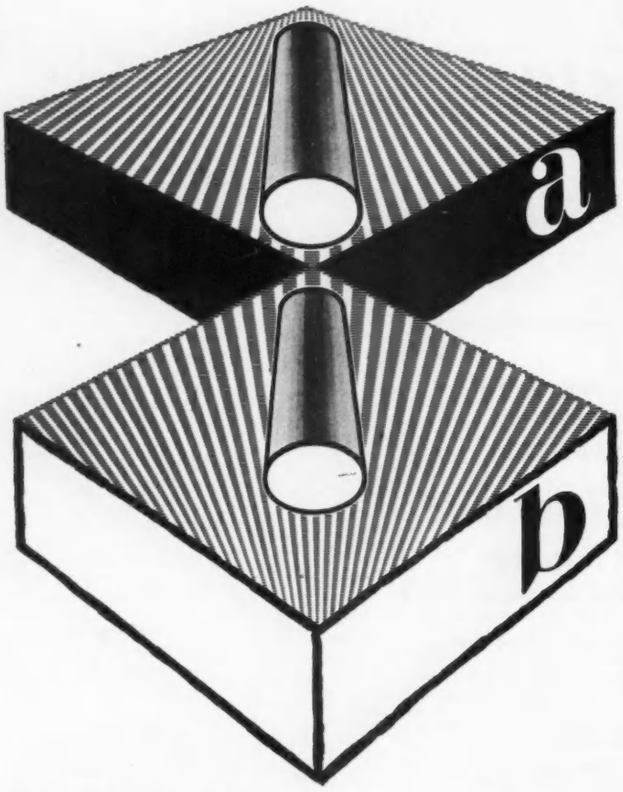

*which is biggest?**

When it's a matter of seamless steel tubes you need look no further than Chesterfield for the right answer. Here we breed a race of giants—the biggest pierced and drawn seamless steel tubes in the whole of Britain. Tubes 25 feet long are a matter of routine with us; internal bores of 39 inches raise not an eyebrow. And bigness is not all. Tubes made by the Chesterfield process are immensely strong. No seam, no welds, no joints . . . and certainly no rivals.

If you want to know which is the bigger tube in the illustration—they're both identical.

***the biggest tubes are**

CHESTERFIELD TUBES

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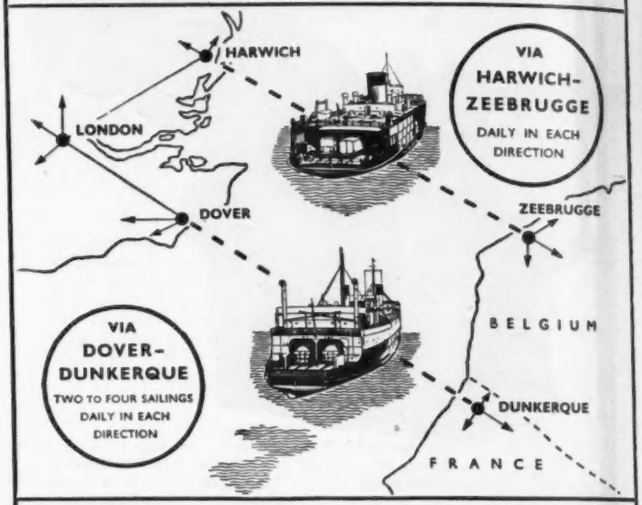

Full particulars from: Continental Superintendent, Victoria Station, London, S.W.1, for Dover route, and from Continental Traffic Manager, Liverpool Street Station, London, E.C.2, for Harwich route.

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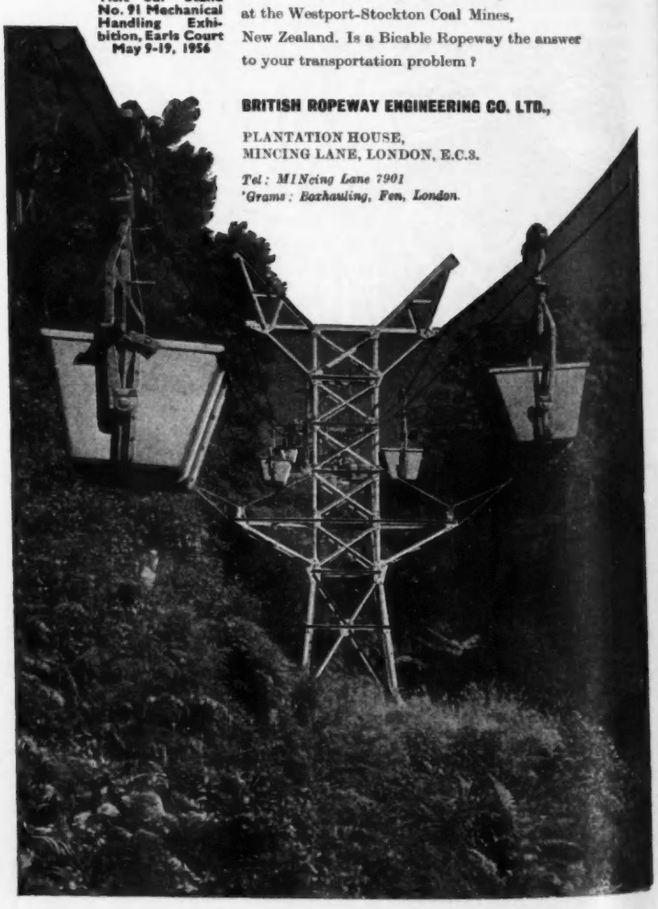

designed for

dependability

The Model 8 is the latest version of the Universal AvoMeter. In addition to the many well known AvoMeter features, such as the automatic overload protection cut-out, dual knob range selection, etc., it has a push button for reversing the polarity of the movement to obviate the inconvenience of changing over the leads when encountering opposite potentials in respect to a common reference point.

The meter has a sensitivity of 20,000 ohms per volt on all D.C. ranges, and 1,000 ohms per volt on A.C. ranges from 100V. upwards. Accuracy on D.C. current ranges and A.C. ranges is to B.S. Spec. 89/1954 and on D.C. voltage ranges within 2% of indication from full scale to half scale deflection, and 1% of full scale value below half scale deflection.

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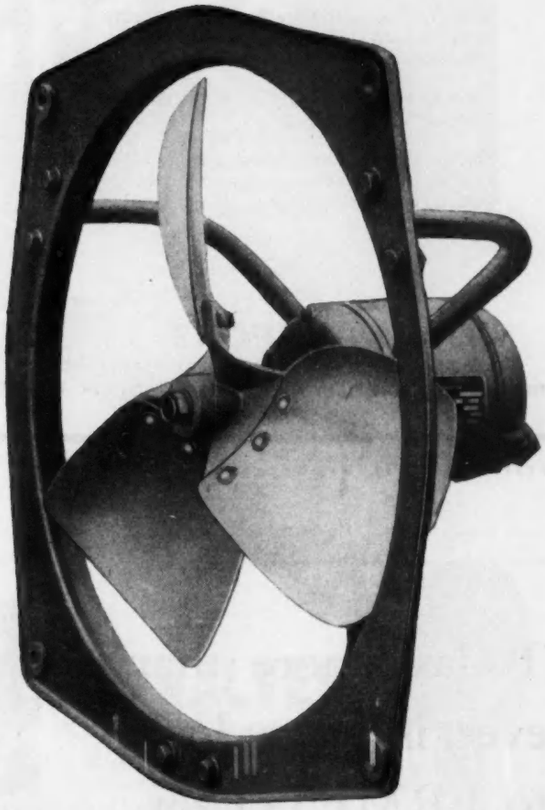

Known as the **type APA** this series represents the peak of achievement in design, performance and price for propeller fans working under free air conditions or against moderate resistances.

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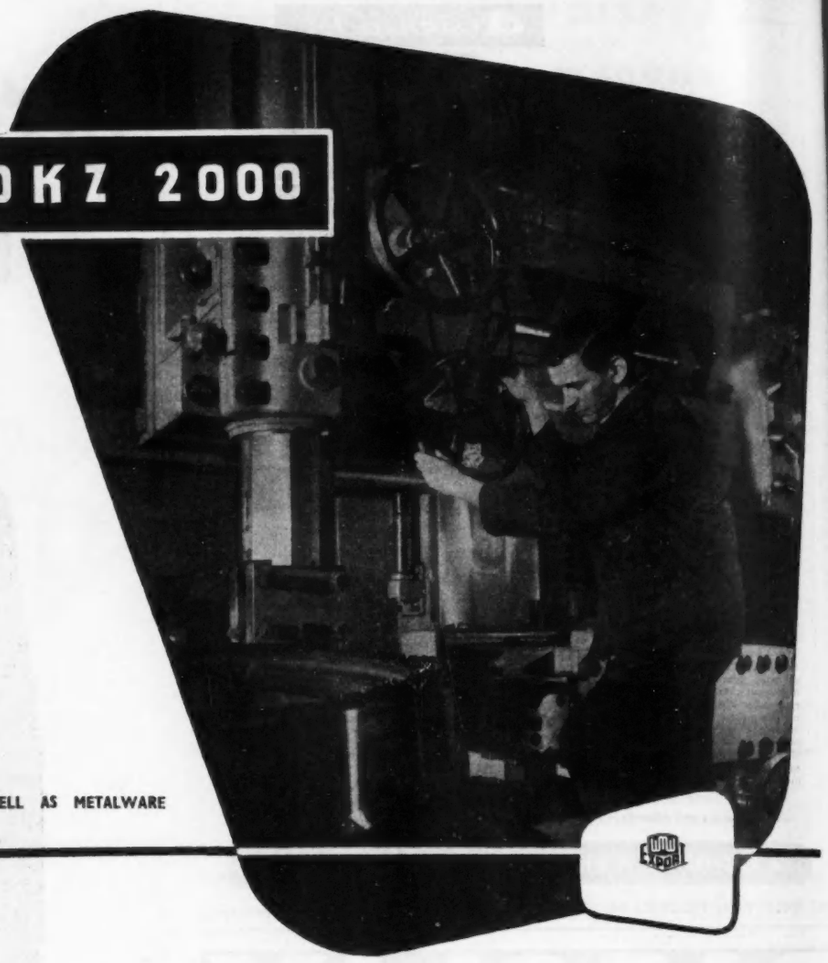

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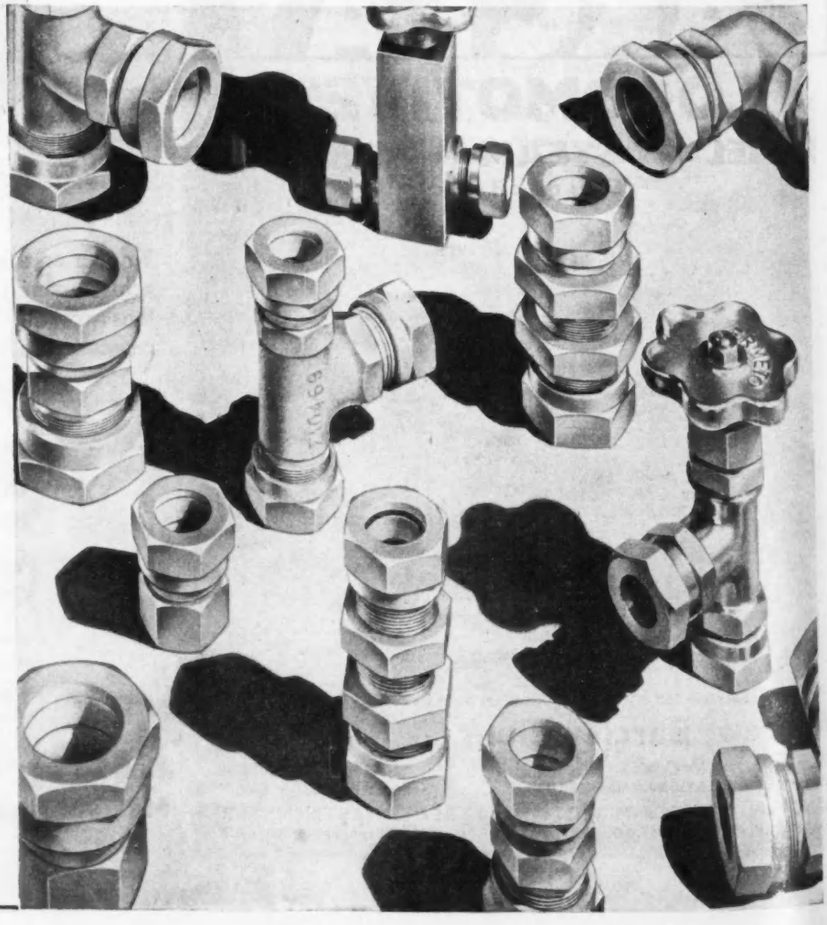

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A 54-inch Bailey Check valve specified for Thornhill Power Station.

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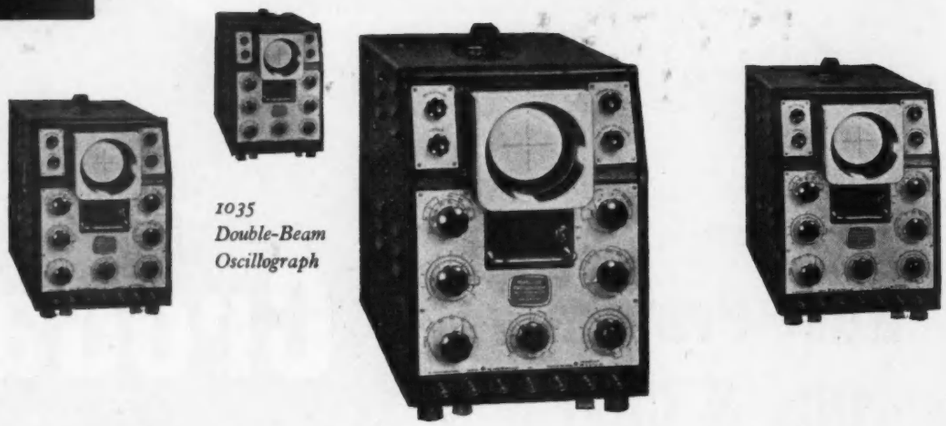
COSSOR DOUBLE-BEAM OSCILLOGRAPHS



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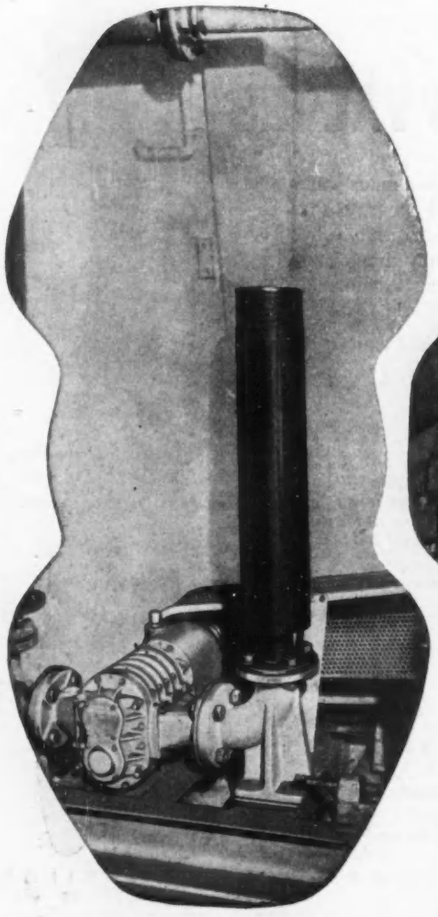

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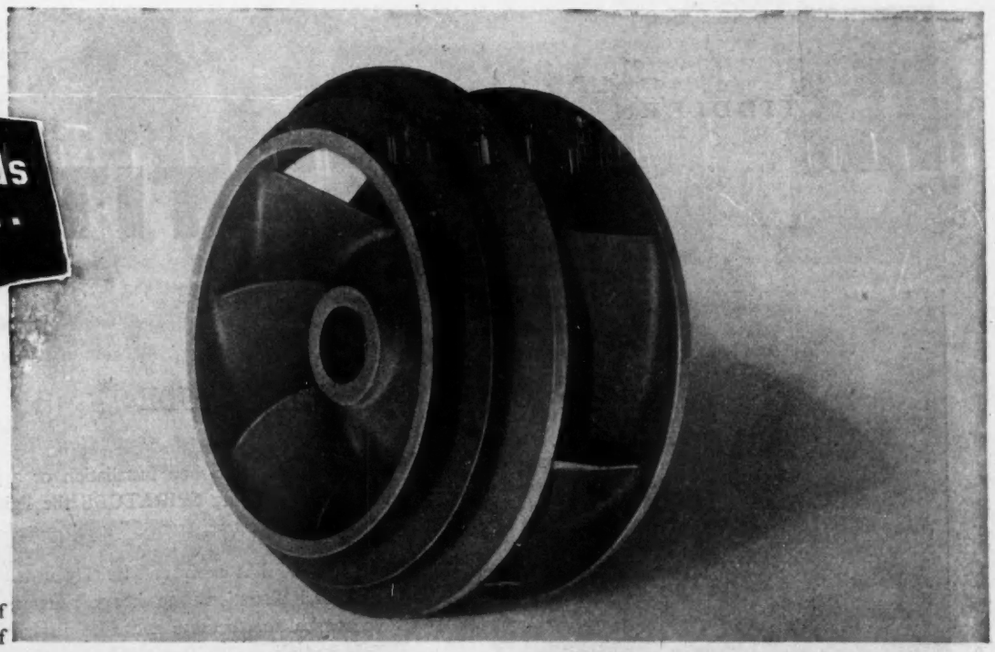

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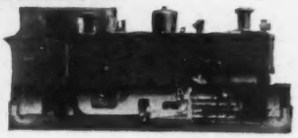
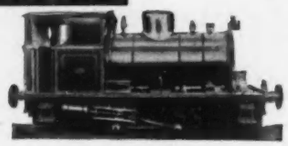
18" x 26" 0-6-0 weight in W.O. 51 tons

OIL-FIRED



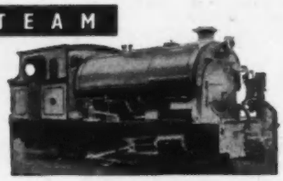
13" x 16" 0-4-2 weight in W.O. 29 tons

FIRELESS



12" x 18" 0-4-0 weight in W.O. 18 tons

STEAM



14" x 22" 0-4-2 weight in W.O. 42 tons

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Oil-fired, Fireless, or for burning Solid Fuel

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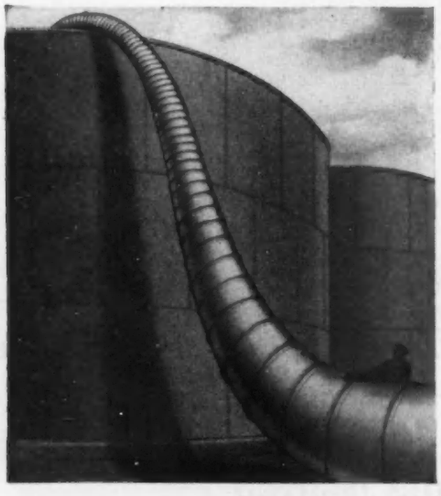
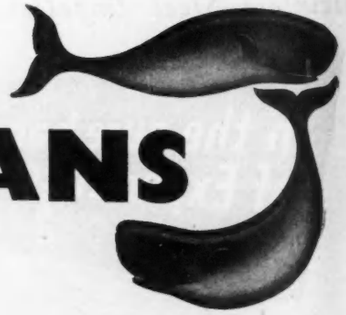


or TITANS



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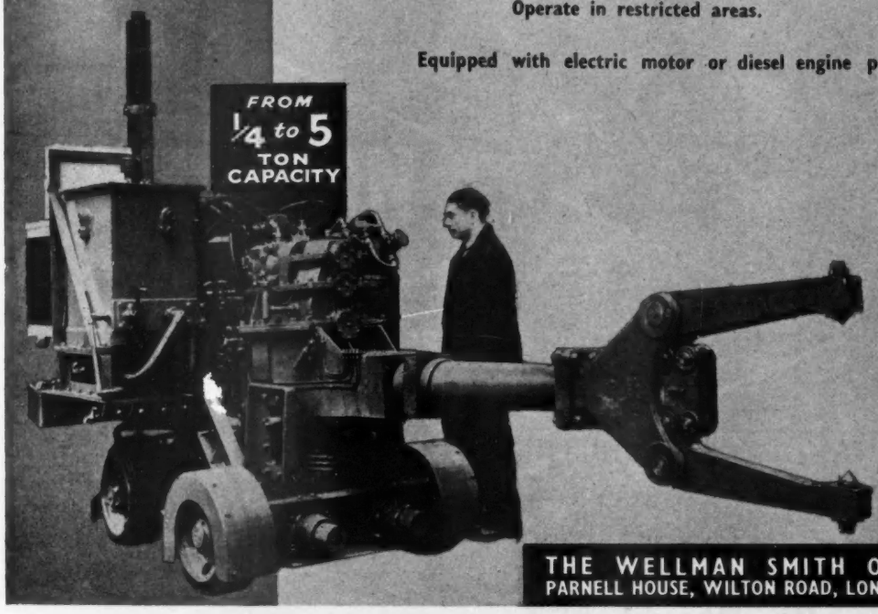

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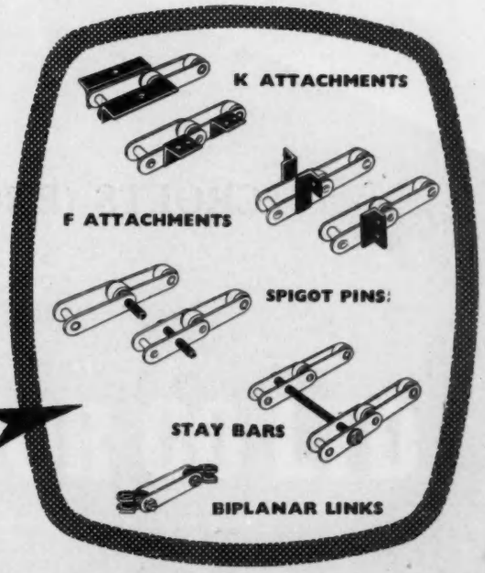

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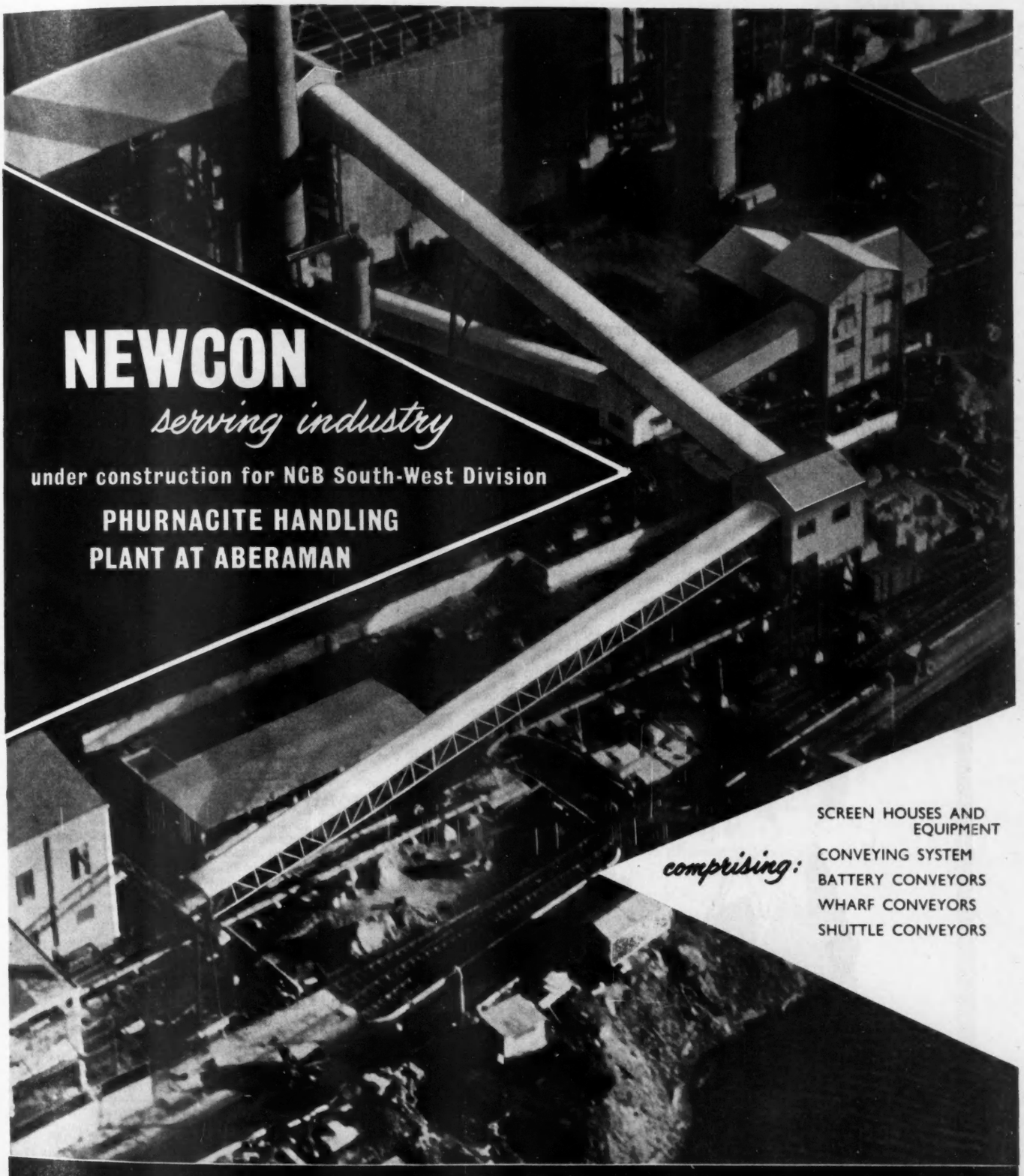

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Meet Ethel Mary Sprott

It's mid-summer and she's sweating and swearing because she's hot. She's getting careless because she's drowsy. She's fed up because the factory's like an oven. What's the trouble? No windows or fans? Not on your life! Feel that roof. It's *baking* hot. No wonder production is slacking off. So what? So . . . *

*wrap her in

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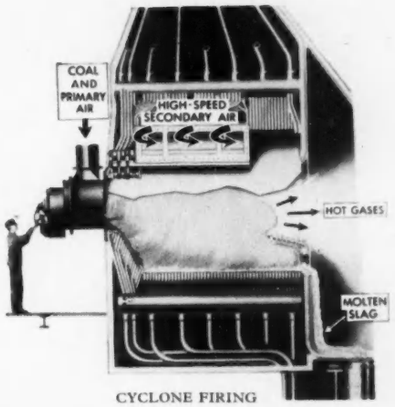
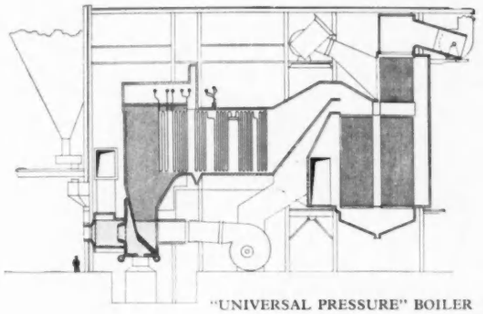


CYCLONE FIRING


"UNIVERSAL PRESSURE" BOILER

CYCLONE FIRING

The revolutionary Cyclone furnace, burning even low-grade coals at high combustion rates with low excess-air and exceptionally high ash-recovery is now fully established as one of the most efficient means of firing large boilers, and offers outstanding operating advantages. Babcock & Wilcox Ltd., have under construction and on order a number of Cyclone-fired boilers for both power station and large industrial installations. Ask for Publication 1508/2.

STEAM GENERATION AT SUPERCRITICAL PRESSURES

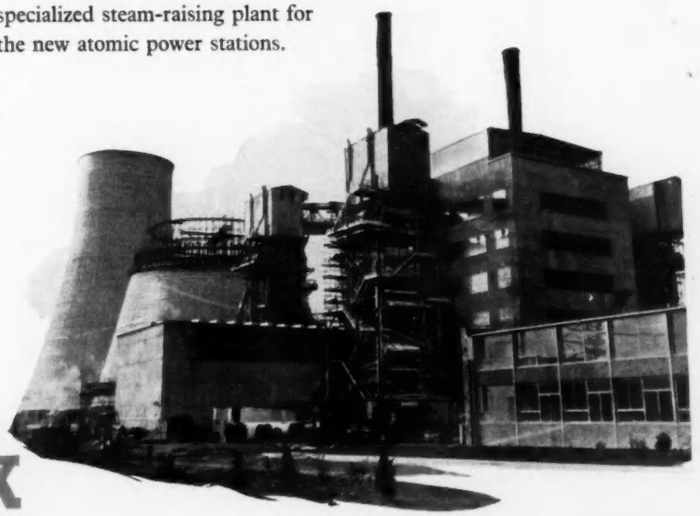
New Babcock developments include the "Universal pressure" boiler which is a 'once through' unit capable of large scale steam generation at pressures extending into the supercritical zone, i.e., to pressures above 3206 lb./sq. in., at which water, on reaching the boiling point, passes directly into steam without change of volume.
Using such plant, central station overall thermal efficiencies are expected of the order of 40%.

STEAM-GENERATING TOWERS FOR CALDER HALL

The fusion-welded, 80 feet high by 17 feet diameter steam-generating towers already manufactured by Babcock & Wilcox Ltd., for the Calder Hall atomic power station, with their complex multiloop banks of stud-tube heat-exchangers, represent a venture into a highly specialized branch of steam-generation in which the Company has been able to apply its existing experience and facilities to the design and manufacture of new and special forms of equipment.

The Company has subsequently received orders approaching £6,000,000 in value for the manufacture of another 24 similar towers for the Calder Hall and Chapel Cross atomic power stations.

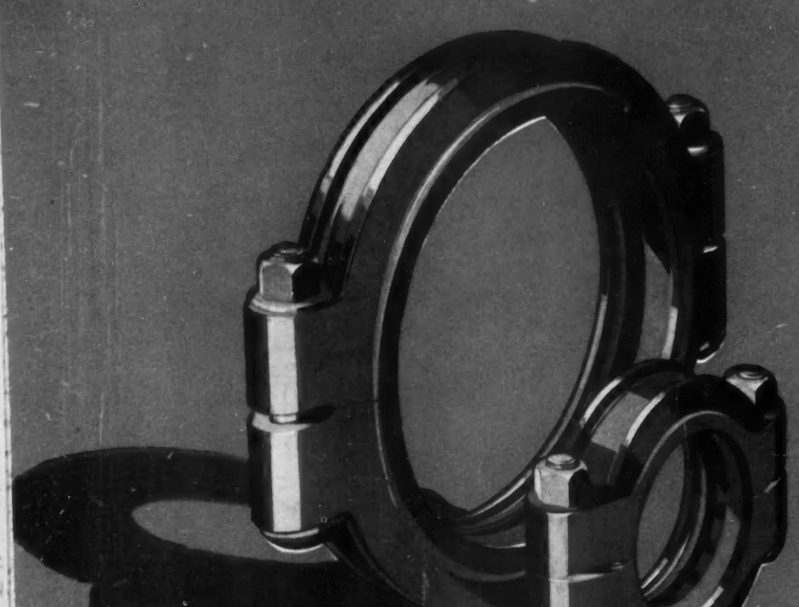
The history of electrical power generation is closely bound up with that of steam engineering and the major advances leading to more efficient, economical and reliable steam power generation, using increasingly low-grade, variable fuels, have been largely due to new developments in steam-raising plant and techniques, in which Babcock & Wilcox have continually led the way. Recent examples are the 'Cyclone' furnace and steam-generation at supercritical pressures, both of the highest importance in the more efficient use of 'conventional' fuels; and, as we move into the age of nuclear power generation, Babcock & Wilcox are again in the forefront with the design and manufacture of highly specialized steam-raising plant for the new atomic power stations.


Calder Hall atomic power station under construction, showing some of the Babcock steam-generating towers

all Babcock

BABCOCK & WILCOX LIMITED, BABCOCK HOUSE, FARRINGDON STREET, LONDON, E.C.4

E



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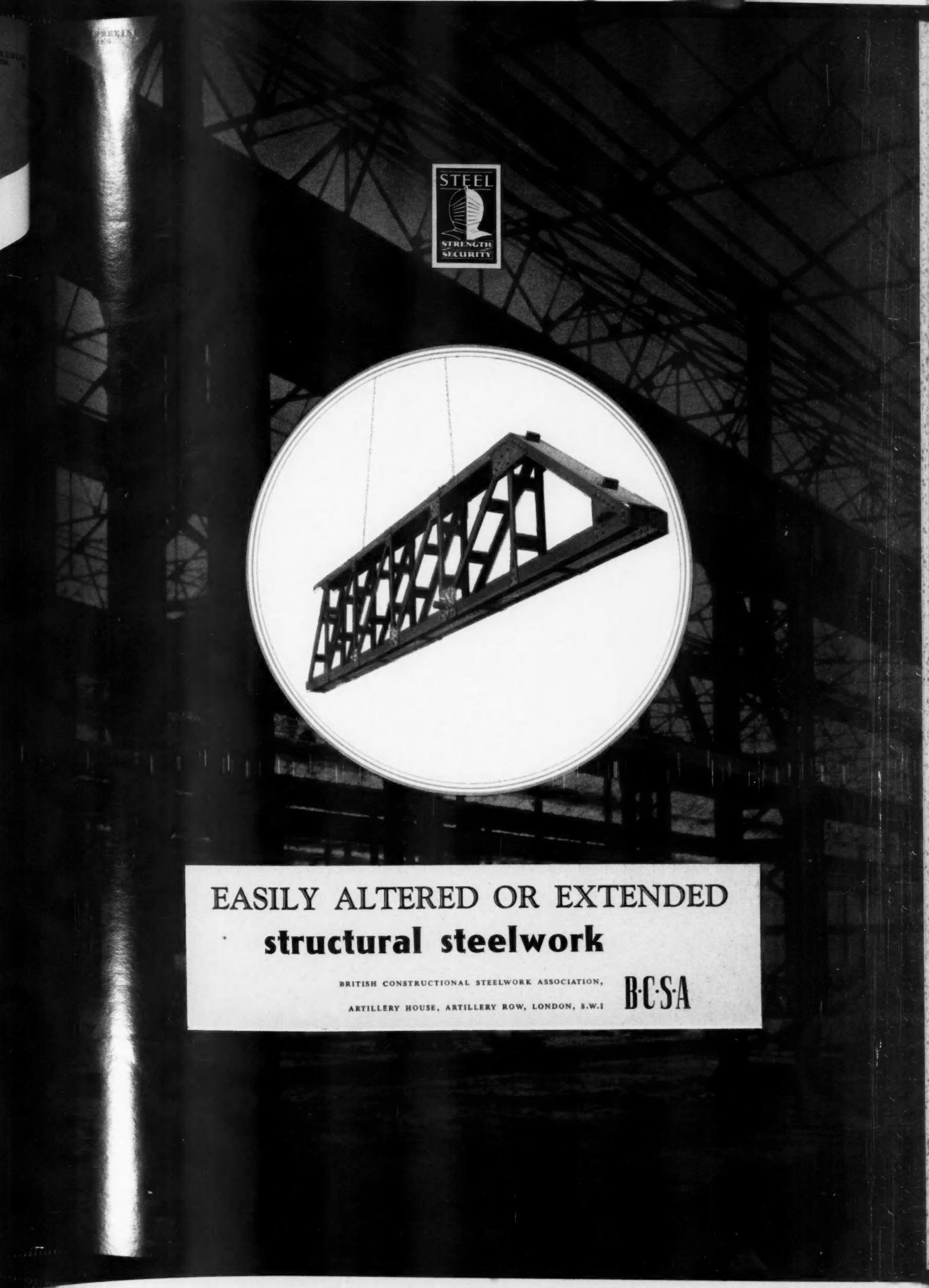

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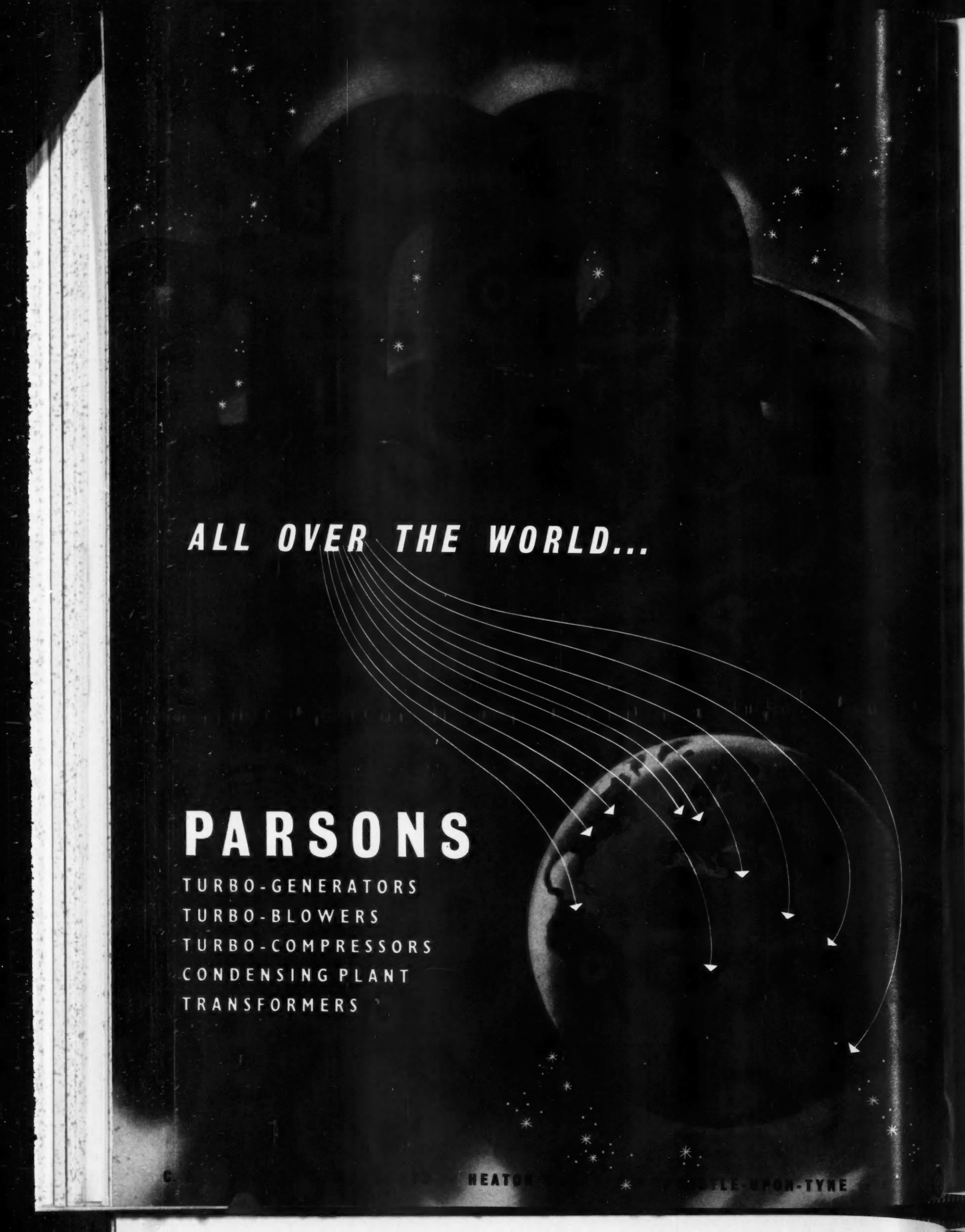
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Cold impact extrusion

... the fastest metal-forming technique

Cold impact extrusion is a fast and economical method of producing hollow containers and complex shapes in non-ferrous and certain ferrous materials.

Save cost and material

Many components now used in industry and produced by a variety of other processes, lend themselves to production by impact extrusion with consequent saving in cost and material. This cold forming process induces added strength in parts by utilising the grain flow, and produces a smooth and flawless finish.

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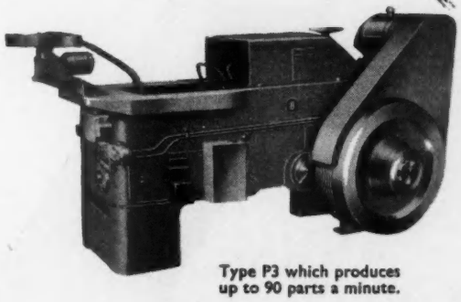
Herlan presses mass-produce accurate extrusions, and machines are available with production rating from 35 to 95 parts a minute. Extrusions up to 4¼" diameter (aluminium) at a wall thickness of 0·011" and maximum length of 12¾" may be obtained from these versatile machines.

Automatic operation

The presses are entirely automatic, and after loading, feed, form, strip-off and eject in rapid sequence. The horizontal working stroke is absolutely smooth and bottom thickness can be adjusted while the press is in motion. Shockless operation promotes long tool life and provision for rapid tool change provides maximum flexibility.



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June 25-July 6
Olympia - London

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FACTORED MACHINE TOOL DIVISION · FLETCHAMSTEAD HIGHWAY · COVENTRY

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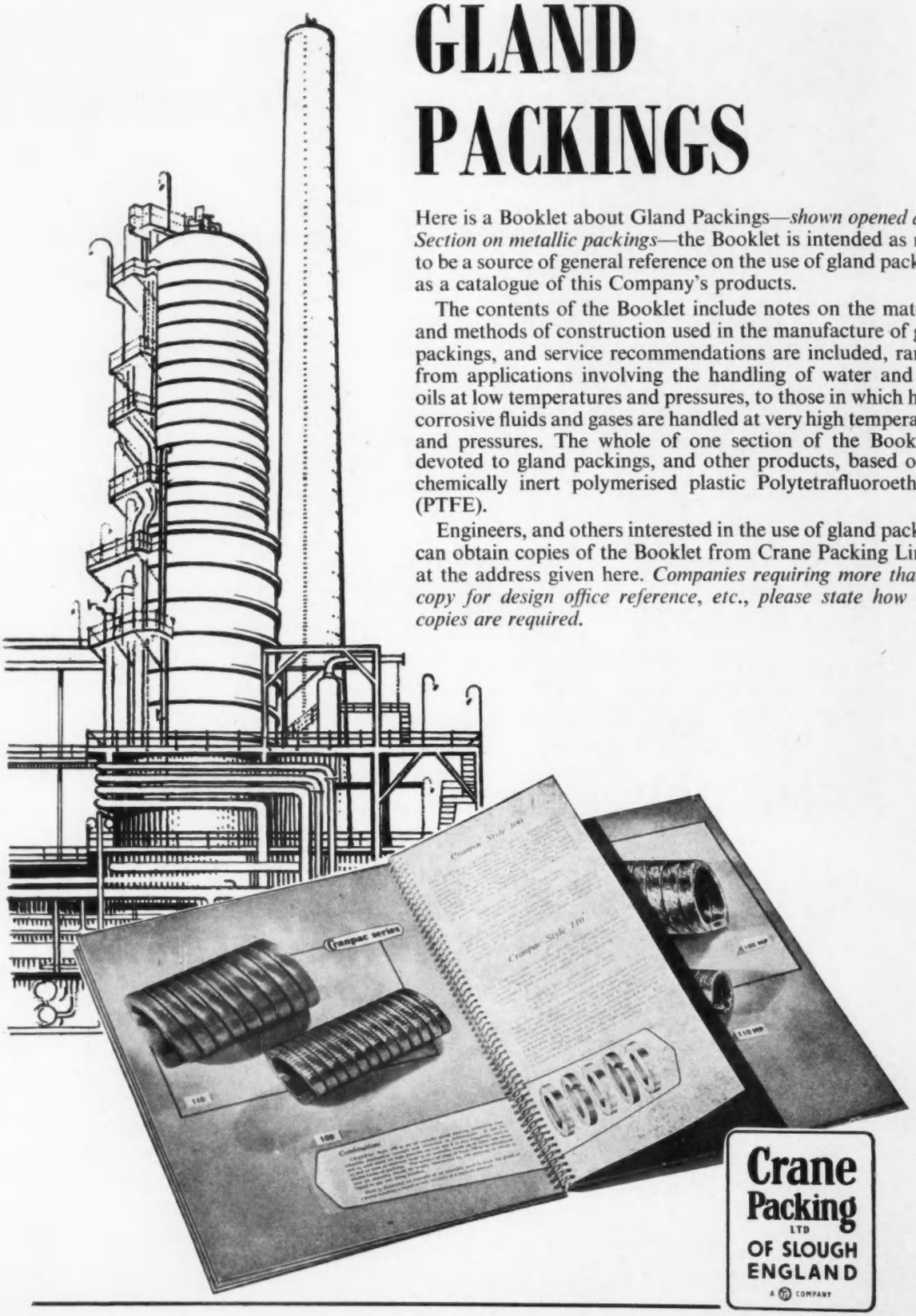

Here is a Booklet about Gland Packings—*shown opened at the Section on metallic packings*—the Booklet is intended as much to be a source of general reference on the use of gland packings, as a catalogue of this Company's products.

The contents of the Booklet include notes on the materials and methods of construction used in the manufacture of gland packings, and service recommendations are included, ranging from applications involving the handling of water and light oils at low temperatures and pressures, to those in which highly corrosive fluids and gases are handled at very high temperatures and pressures. The whole of one section of the Booklet is devoted to gland packings, and other products, based on the chemically inert polymerised plastic Polytetrafluoroethylene (PTFE).

Engineers, and others interested in the use of gland packings, can obtain copies of the Booklet from Crane Packing Limited at the address given here. *Companies requiring more than one copy for design office reference, etc., please state how many copies are required.*

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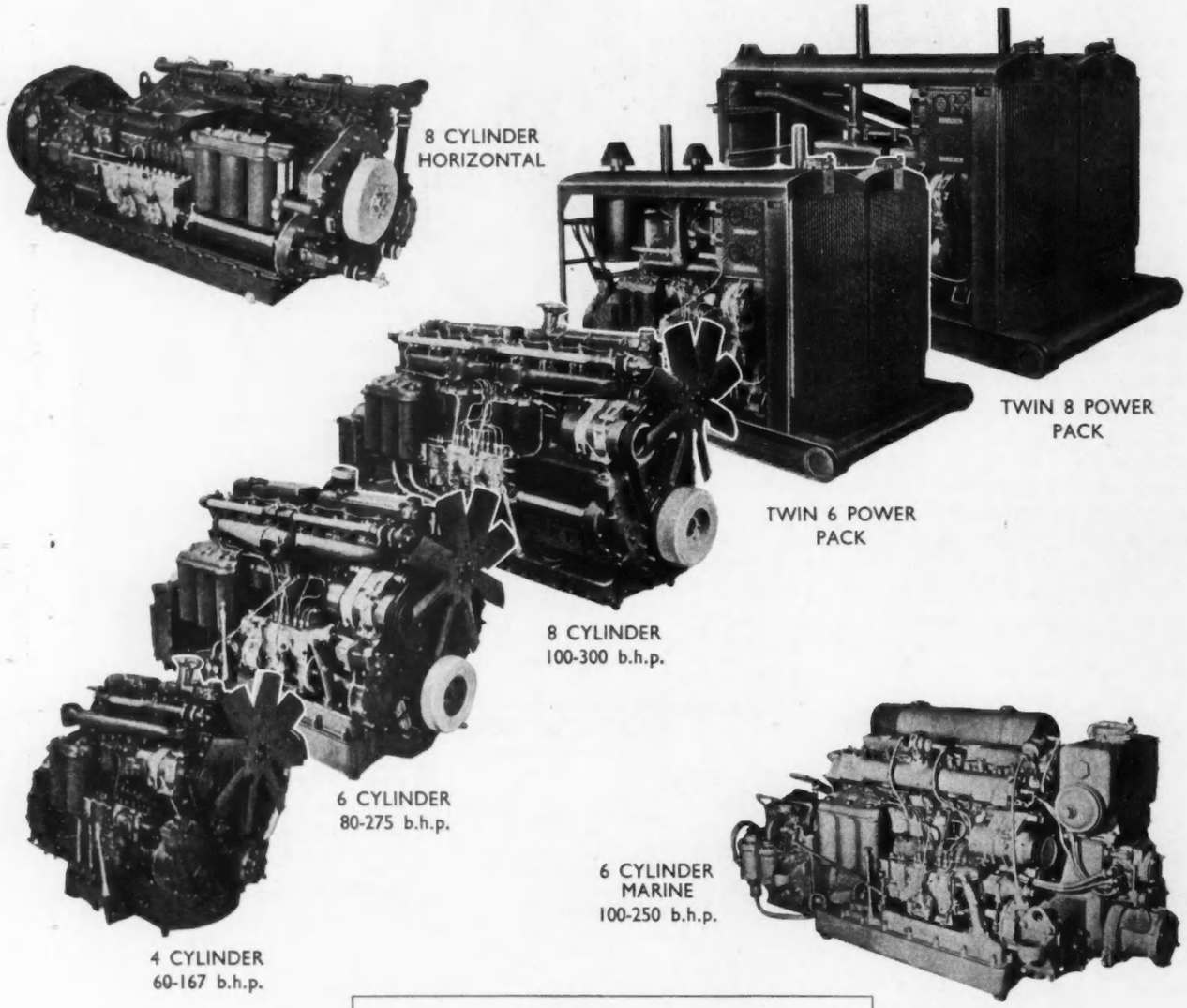

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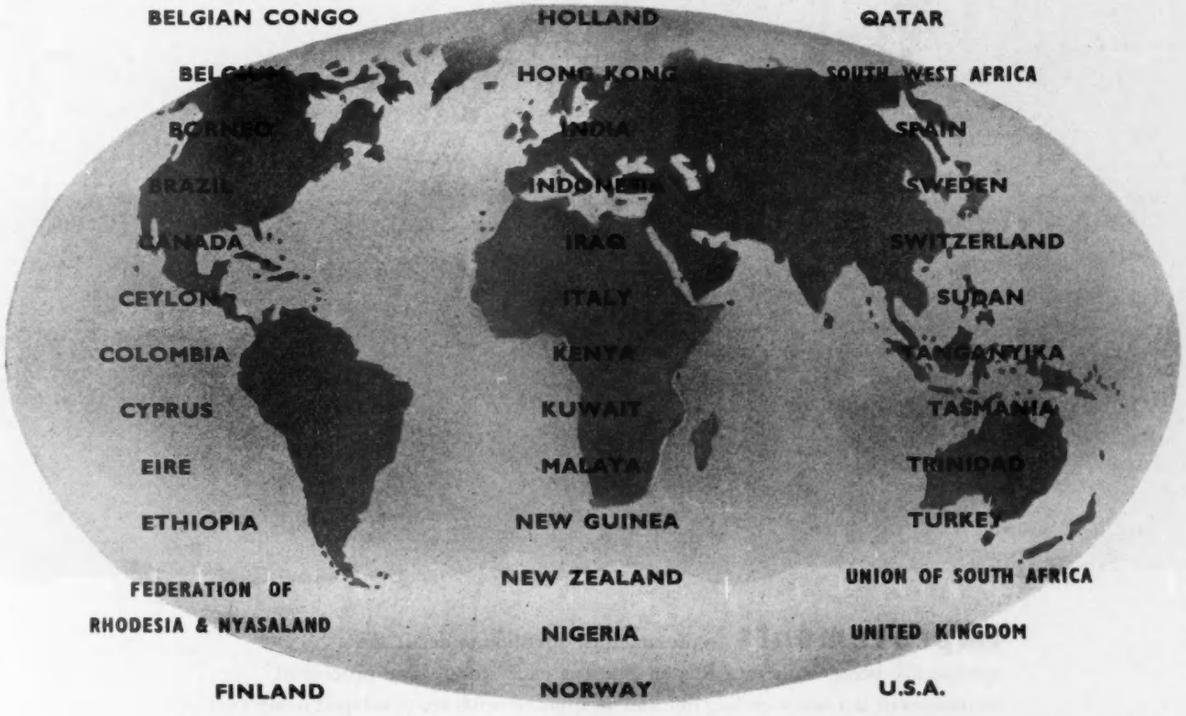

ROLLS-ROYCE

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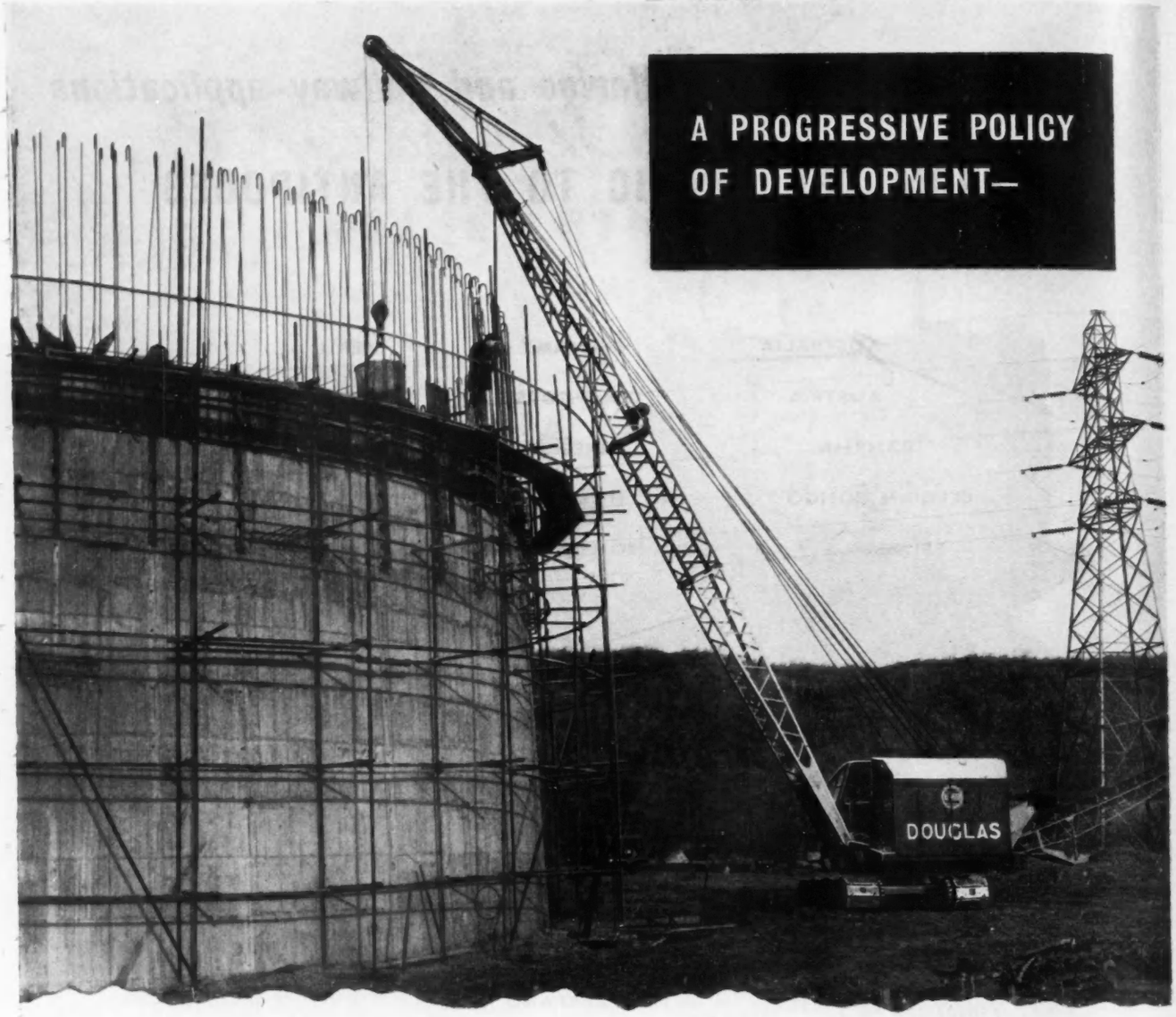

Improvements represented by attention to detail, are continually being built into Ruston-Bucyrus excavators. The process of development is a never-ending one and as improvements are developed so are they incorporated in the complete range of Ruston-Bucyrus excavators up to 6 cu. yds. capacity.

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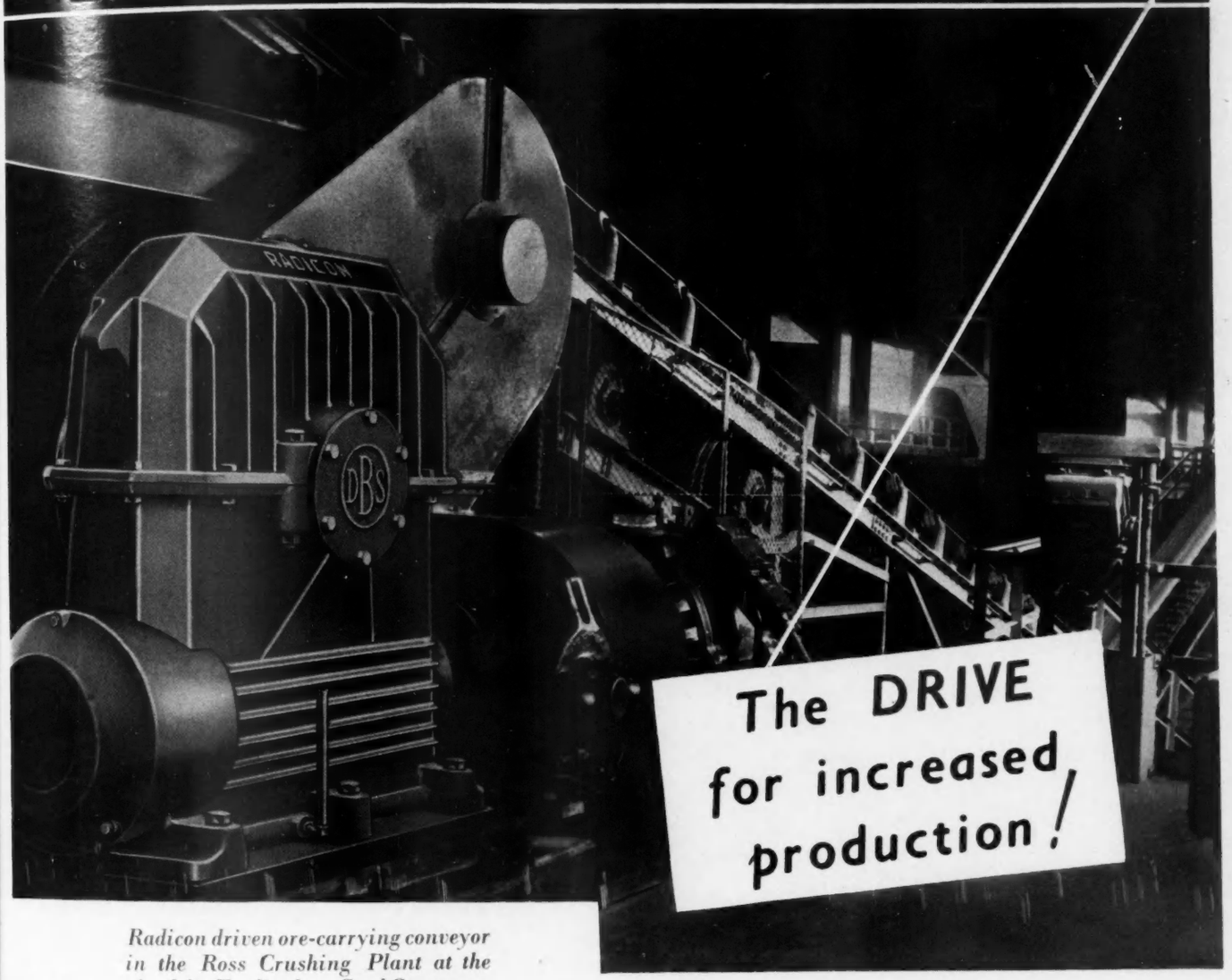

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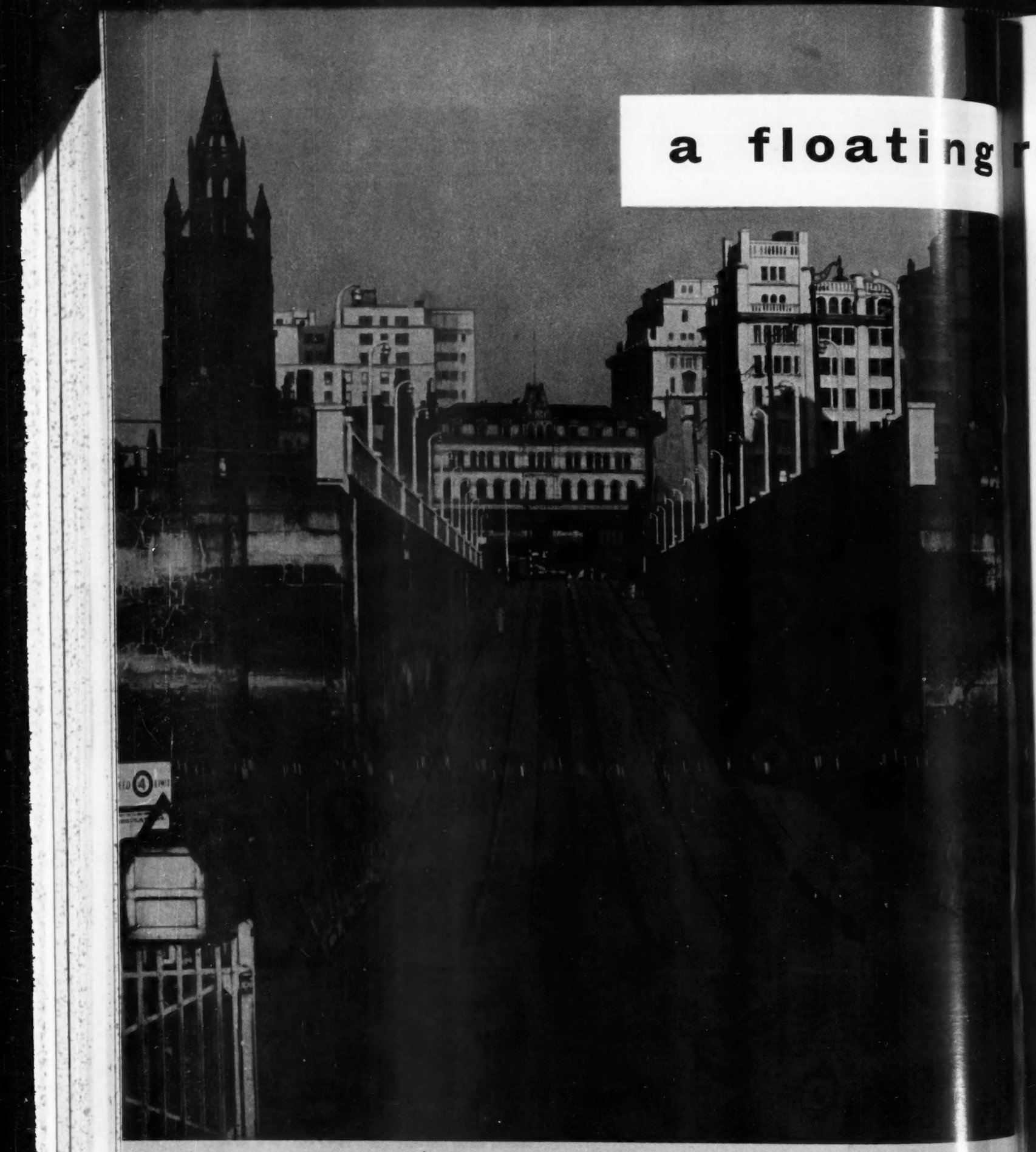

Floating Roadway, Victoria
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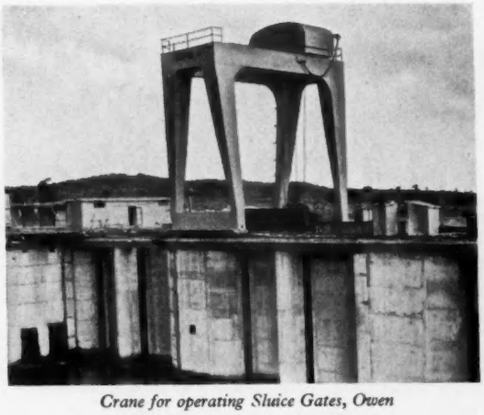
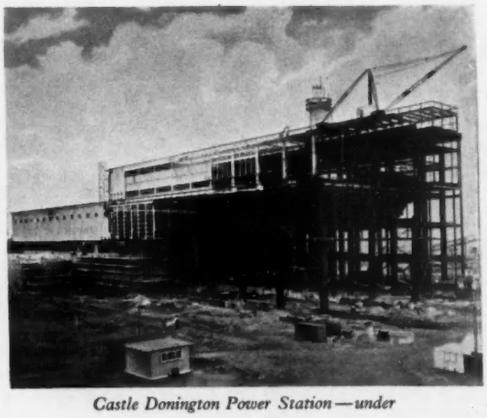
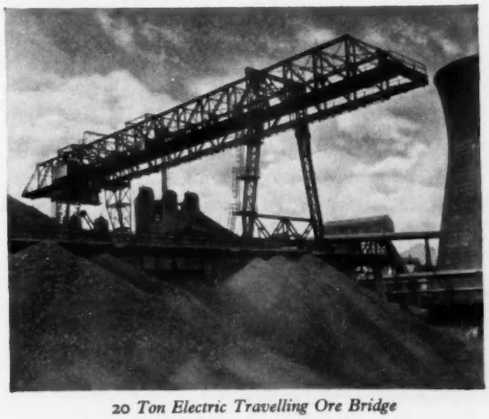


Crane for operating Sluice Gates, Owen Falls Hydro-Electric Station, Uganda



Castle Donington Power Station—under construction



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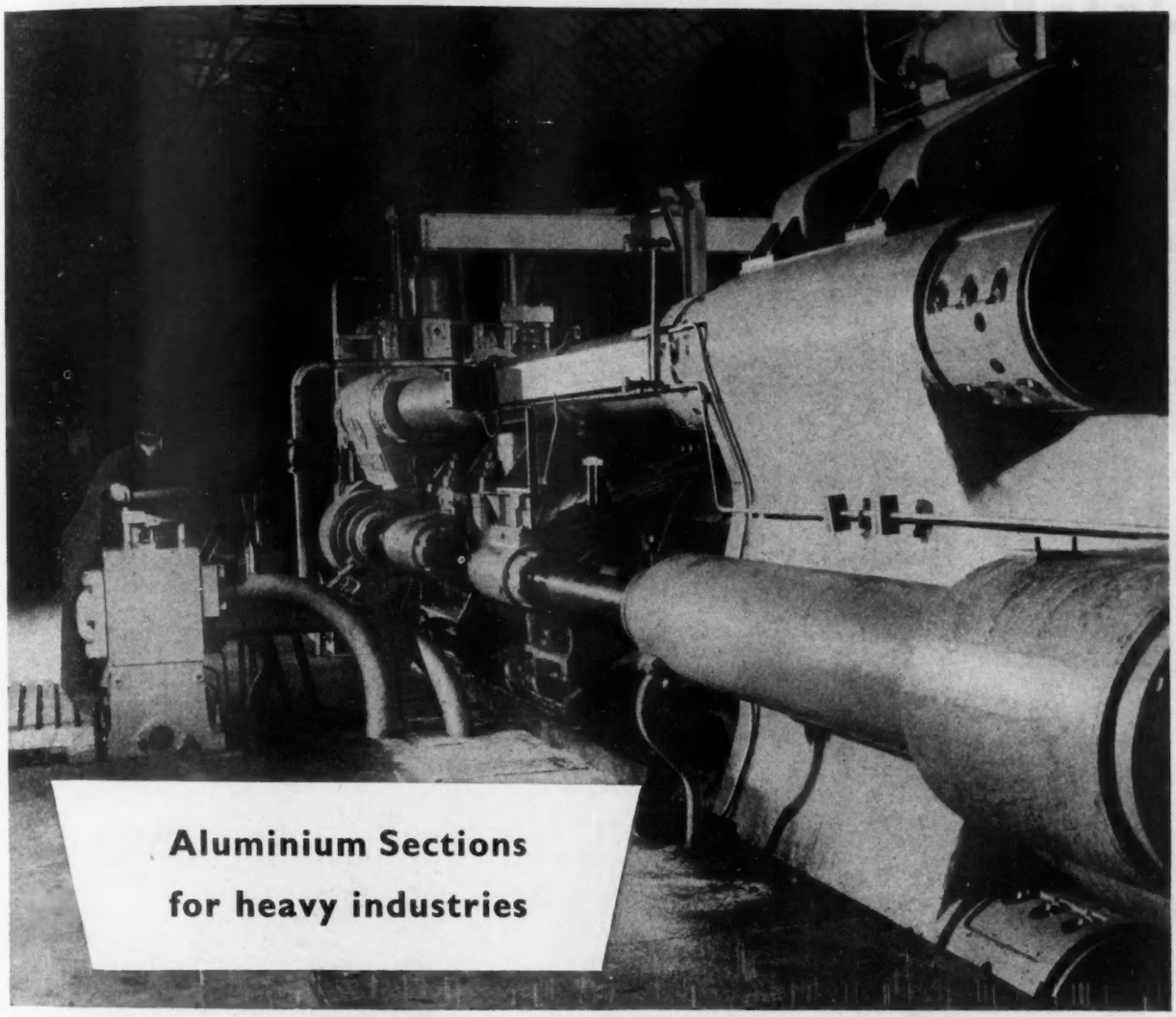

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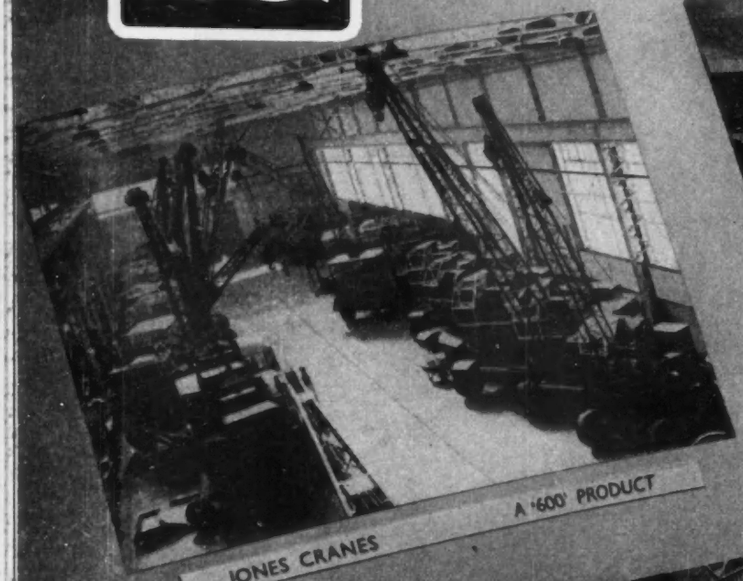

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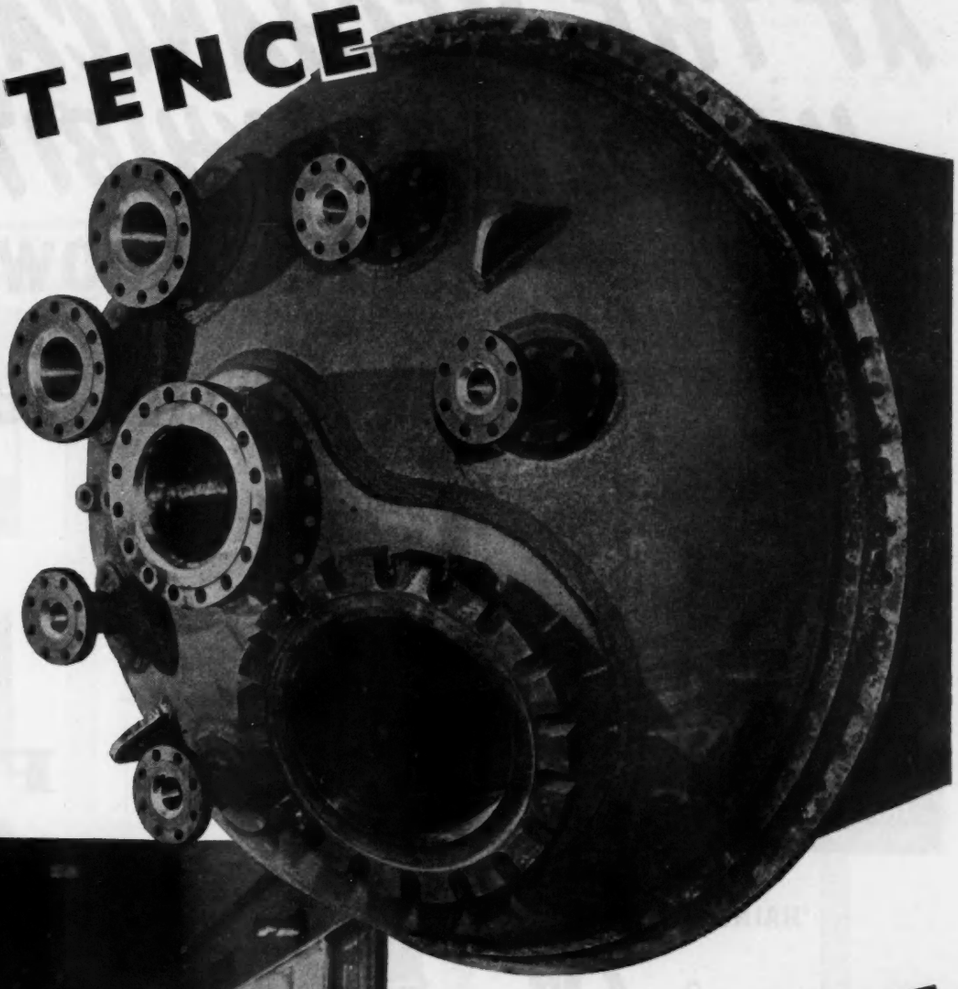

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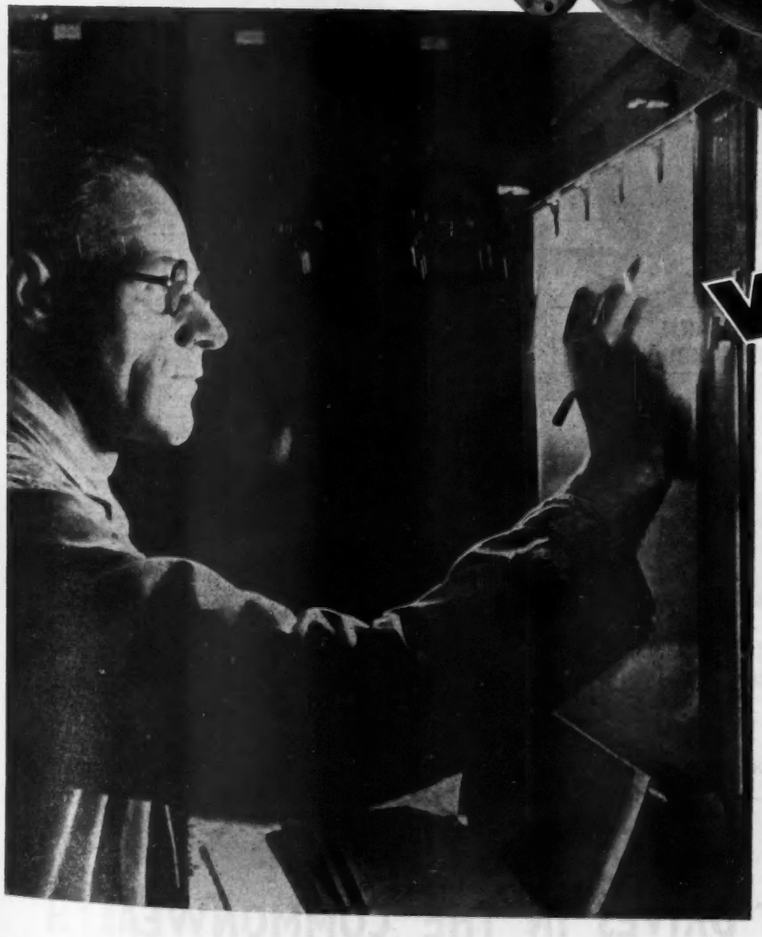

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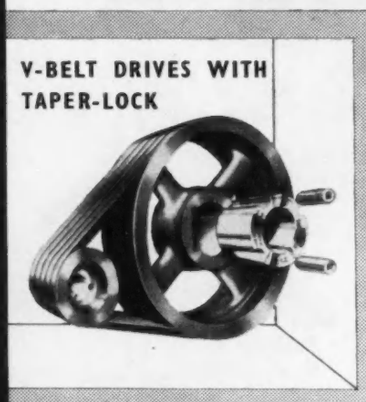

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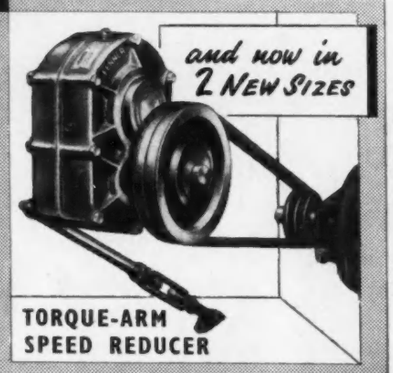

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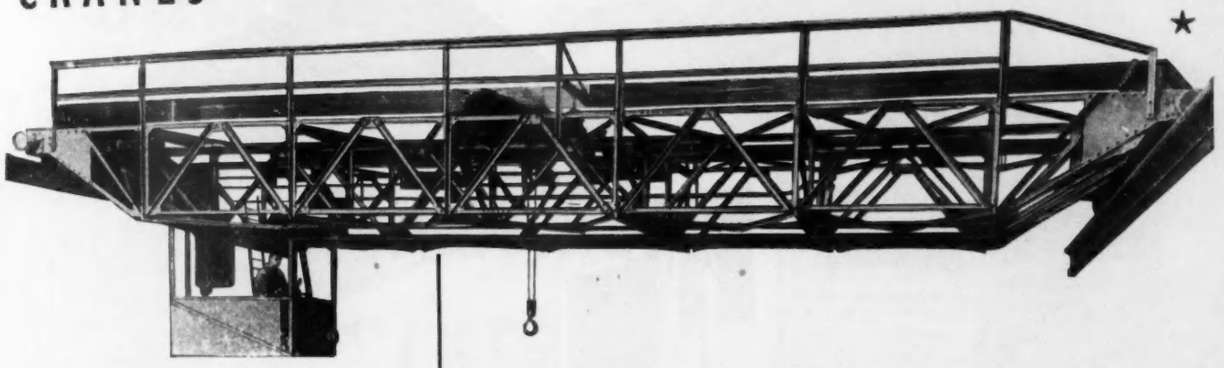

THE designs of the electric overhead cranes that we build are standardised for the obvious reason that standardisation leads to production economies. But, primarily, we are specialists in custom-built lifting gear and these designs permit adaptation in order that the requirements of special site conditions generally may be satisfied without recourse to entirely new design.

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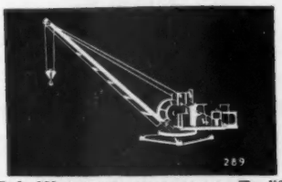
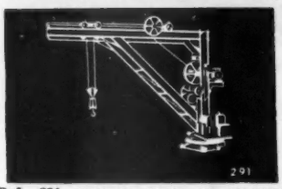


Ref. 289 ELECTRIC WHARF CRANE. To lift 2 to 5 tons. Power Hoisting and Slewing.



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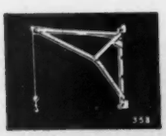

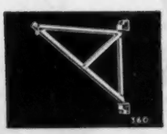

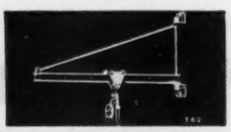

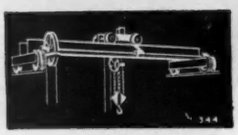

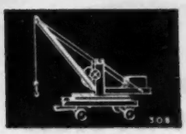

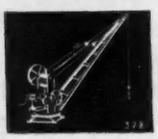

Ref. 344 HAND-OPERATED DOUBLE GIRDER OVERHEAD CRANE. Supplied in a range of standard sizes to lift 1 to 15 tons.

Ref. 308 PORTABLE HAND CRANE to lift from ½ to 3 tons.

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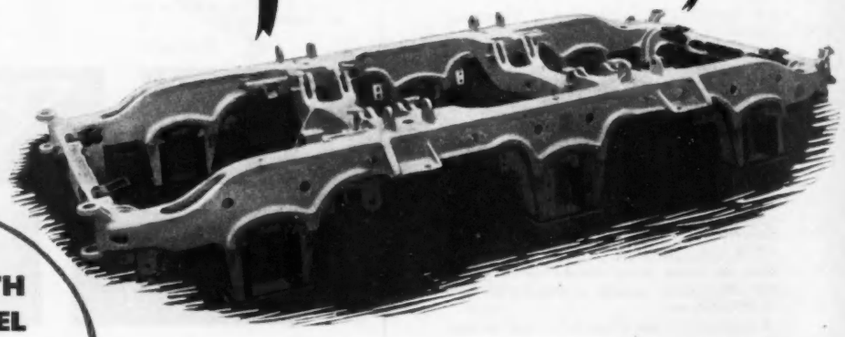

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are designed to provide exceptional strength with the minimum weight. Engineers of Irish State Railways (Coras Iompair Eireann) specified these 'Commonwealth' type bogie frames for the Metropolitan-Vickers diesel electric locomotives built for them by Metropolitan-Cammell Carriage & Wagon Co., Ltd.

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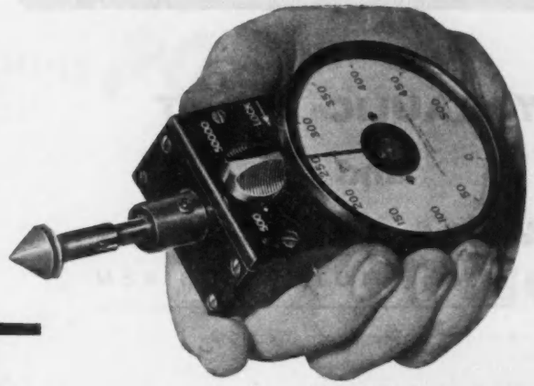
River Don Works, Sheffield

A wholly owned subsidiary of English Steel Corporation Ltd

That most versatile Instrument — *the Hand Tachometer*

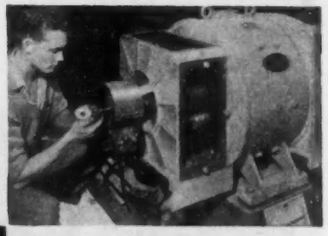


The SMITHS Hand Tachometer is used by such a wide variety of industries and trades and for so many different purposes, that to mention a few applications is but scratching the surface. Its users range from major industries to small workshops and include manufacturers of hair nets, toffee, umbrellas, slippers and—quite likely, candlestickmakers.

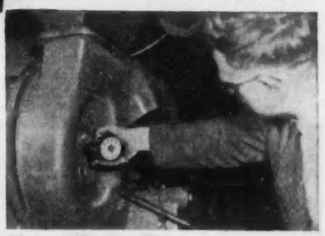
Briefly, Smiths Hand Tachometers provide a ready and accurate check on rotational and surface speeds. Their use is a safeguard against excessive wear of plant and uneconomical operation.

The Hand Tachometer serves Industry

A Hand Tachometer is shown here at a G.E.C. factory, measuring rotational speed during the normal testing of a 10 kW, 125 volt exciter.



In this instance, the English Steel Corporation Ltd. are using a Hand Tachometer to indicate the surface speed of a test bar during a turning tool investigation.

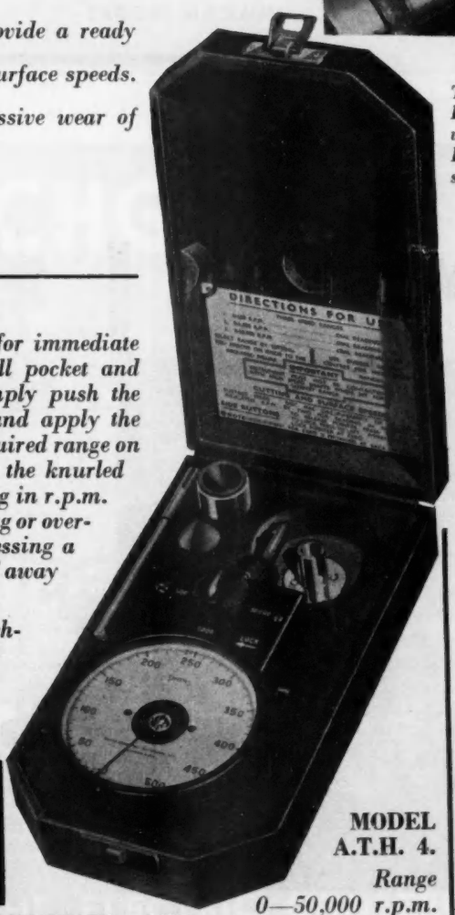


This picture shows a Hand Tachometer in use by 'English Electric' for rating superchargers.

Using the Hand Tachometer

The instrument is always ready for immediate use. It can be slipped into an overall pocket and carried as easily as a slide-rule. Simply push the appropriate attachment on to spindle and apply the instrument to the belt or shaft. The required range on each Tachometer is selected by turning the knurled knob and the dial gives the correct reading in r.p.m. or f.p.m. Under conditions of bad lighting or overhang, the pointer can be locked by depressing a button. The reading can then be observed away from the take-off point.

EACH SET COMPRISES Hand Tachometer, male rubber centre, female rubber centre, three-inch extension piece, disc for surface and cutting speeds (for reading in either feet or metres)



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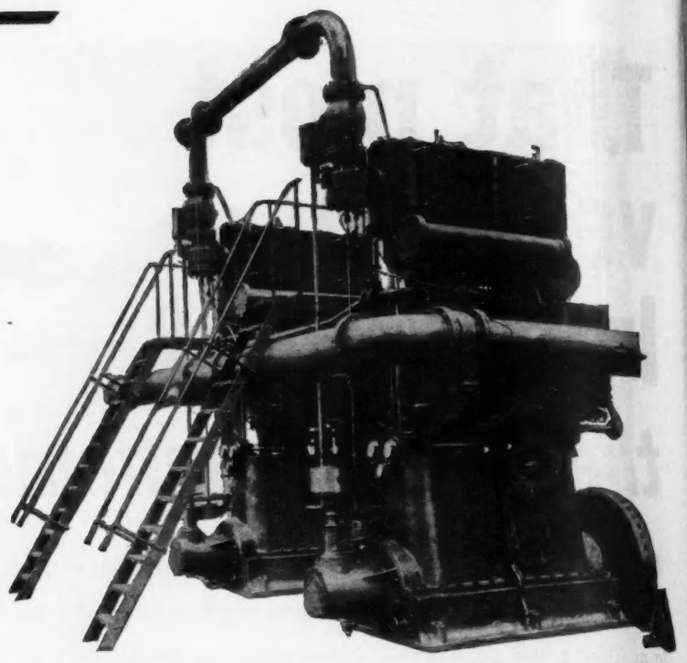

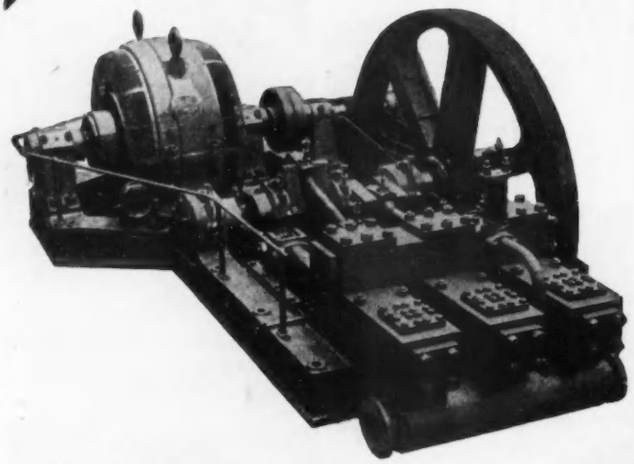

Left: One of a set of six motor driven, horizontal, three throw, single acting, Hydraulic Pumps made for the Port of London Authority.

Above: Two vertical, two crank, single stage, Gas Compressors; 3,333 cu. ft. per minute to 20 lbs. per sq. in.; r.p.m. 300; made for Dundee Corporation Gas Department.

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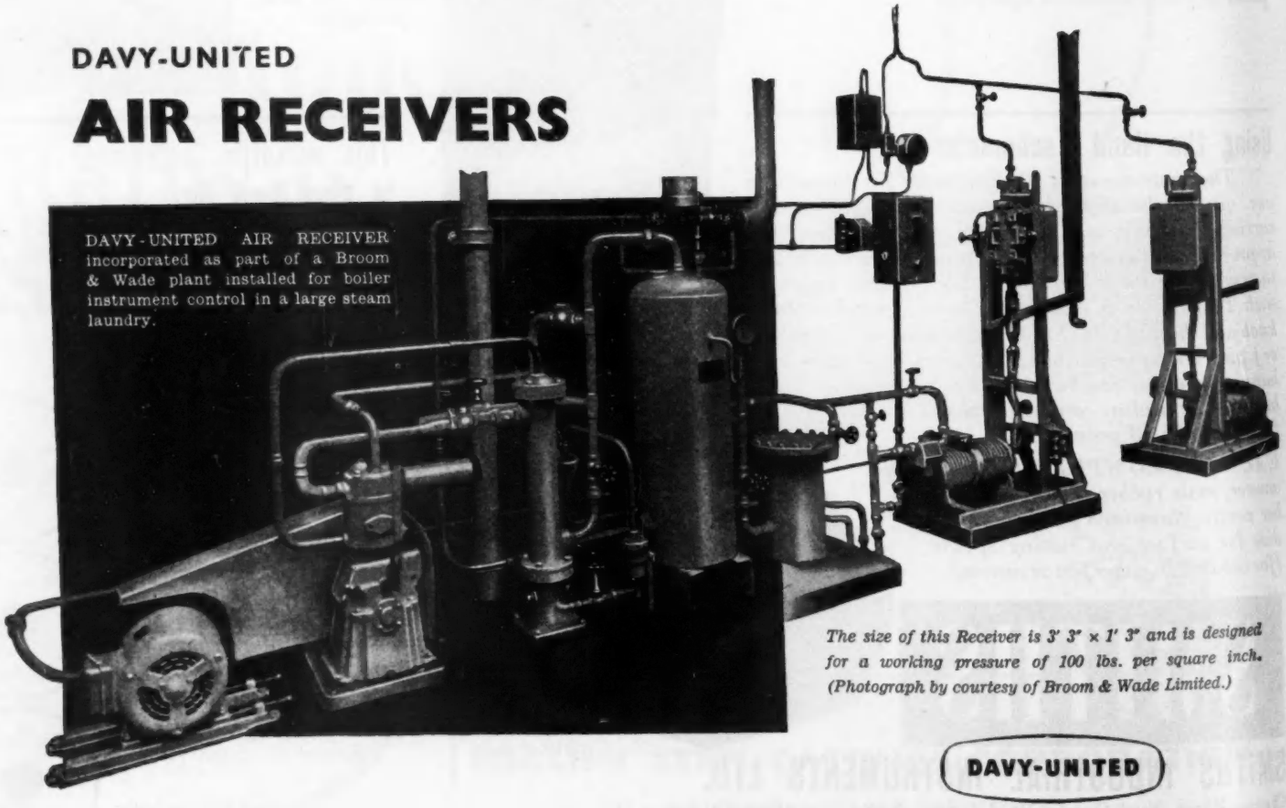
DAVY-UNITED
AIR RECEIVERS



DAVY-UNITED AIR RECEIVER incorporated as part of a Broom & Wade plant installed for boiler instrument control in a large steam laundry.

The size of this Receiver is 3' 3" × 1' 3" and is designed for a working pressure of 100 lbs. per square inch. (Photograph by courtesy of Broom & Wade Limited.)

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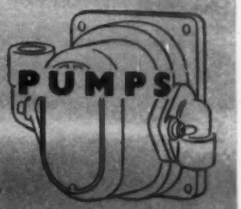

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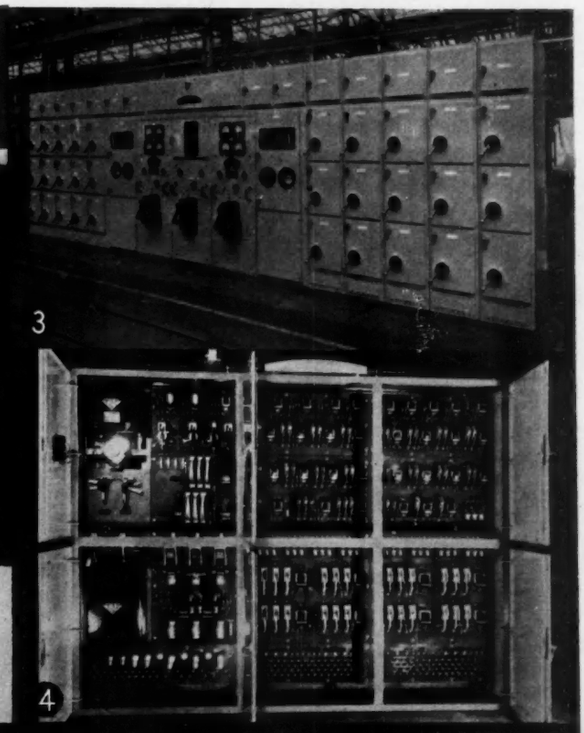

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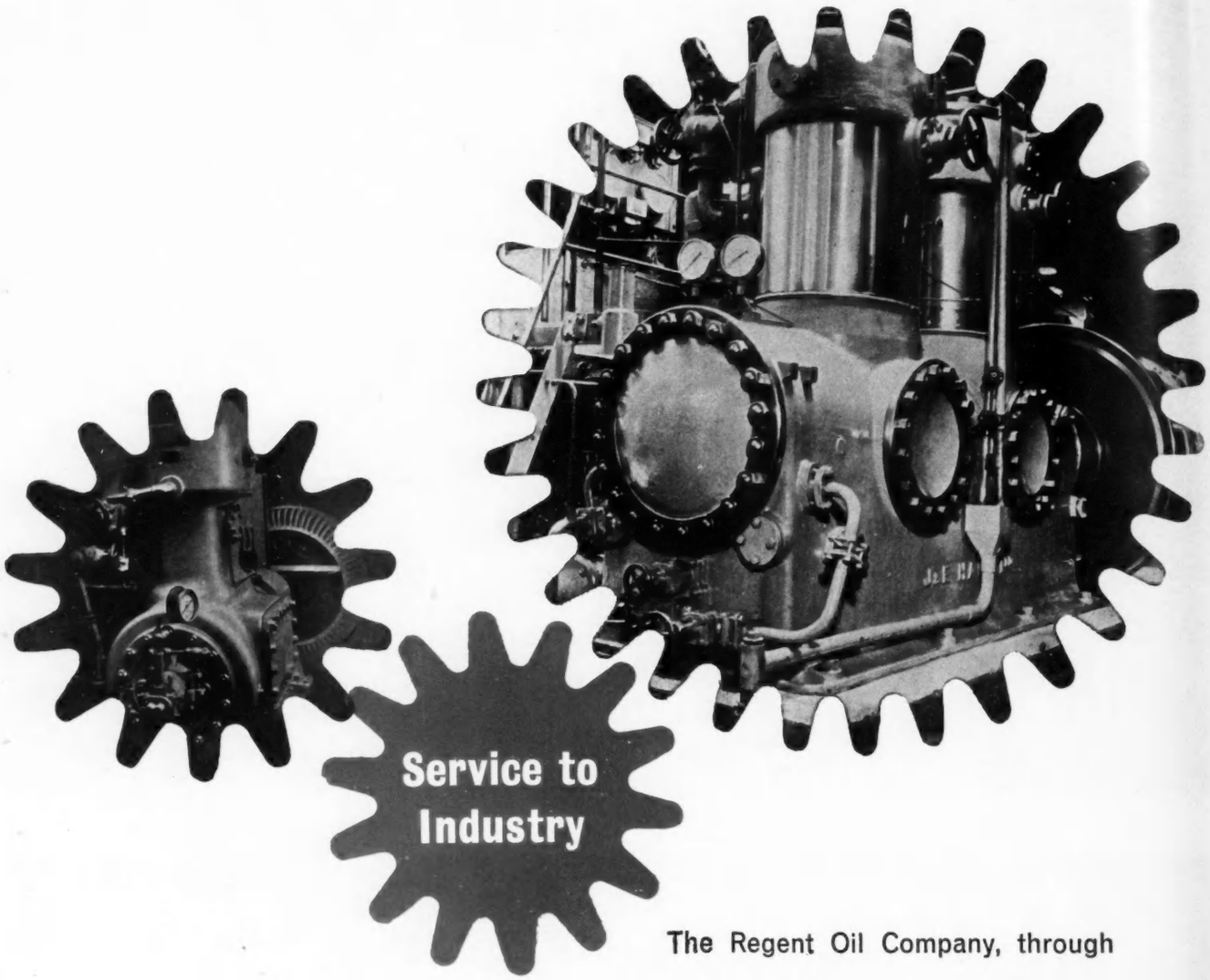

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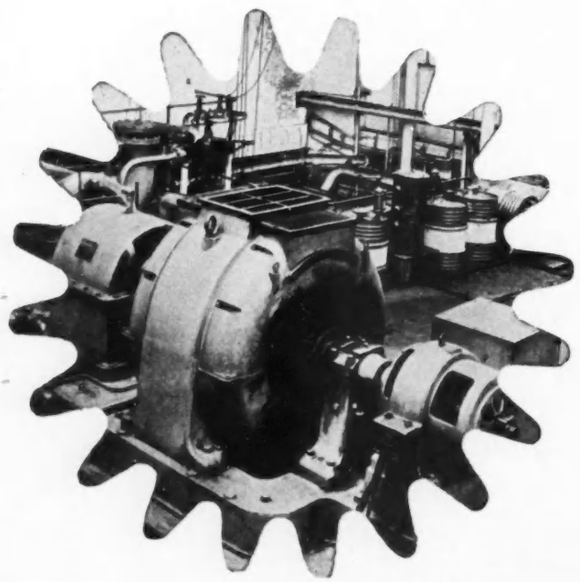

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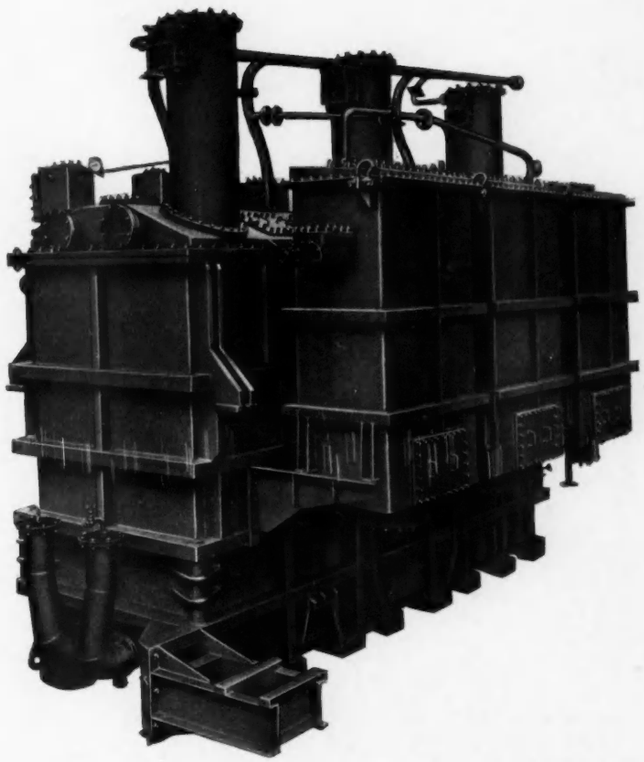

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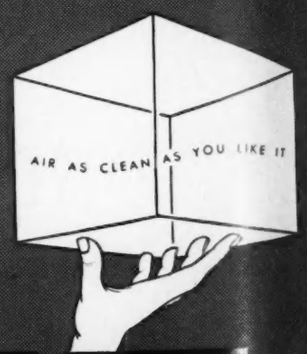

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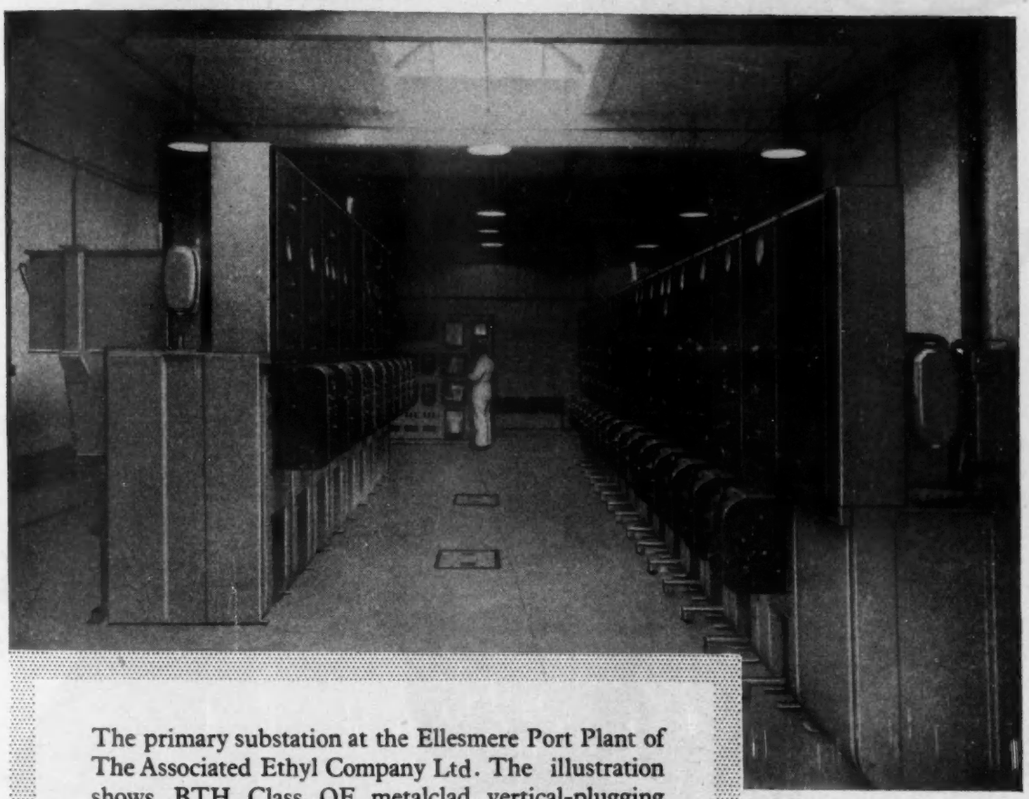

The primary substation at the Ellesmere Port Plant of The Associated Ethyl Company Ltd. The illustration shows BTH Class QF metalclad vertical-plugging switchboards controlling the 11-kV main incoming and rectifier-plant circuits.

BTH switchgear in this installation includes :— fifty-seven 11-kV, 250-MVA equipments; nine 11-kV, 350-MVA equipments; ninety 415 V, 25-MVA equipments.

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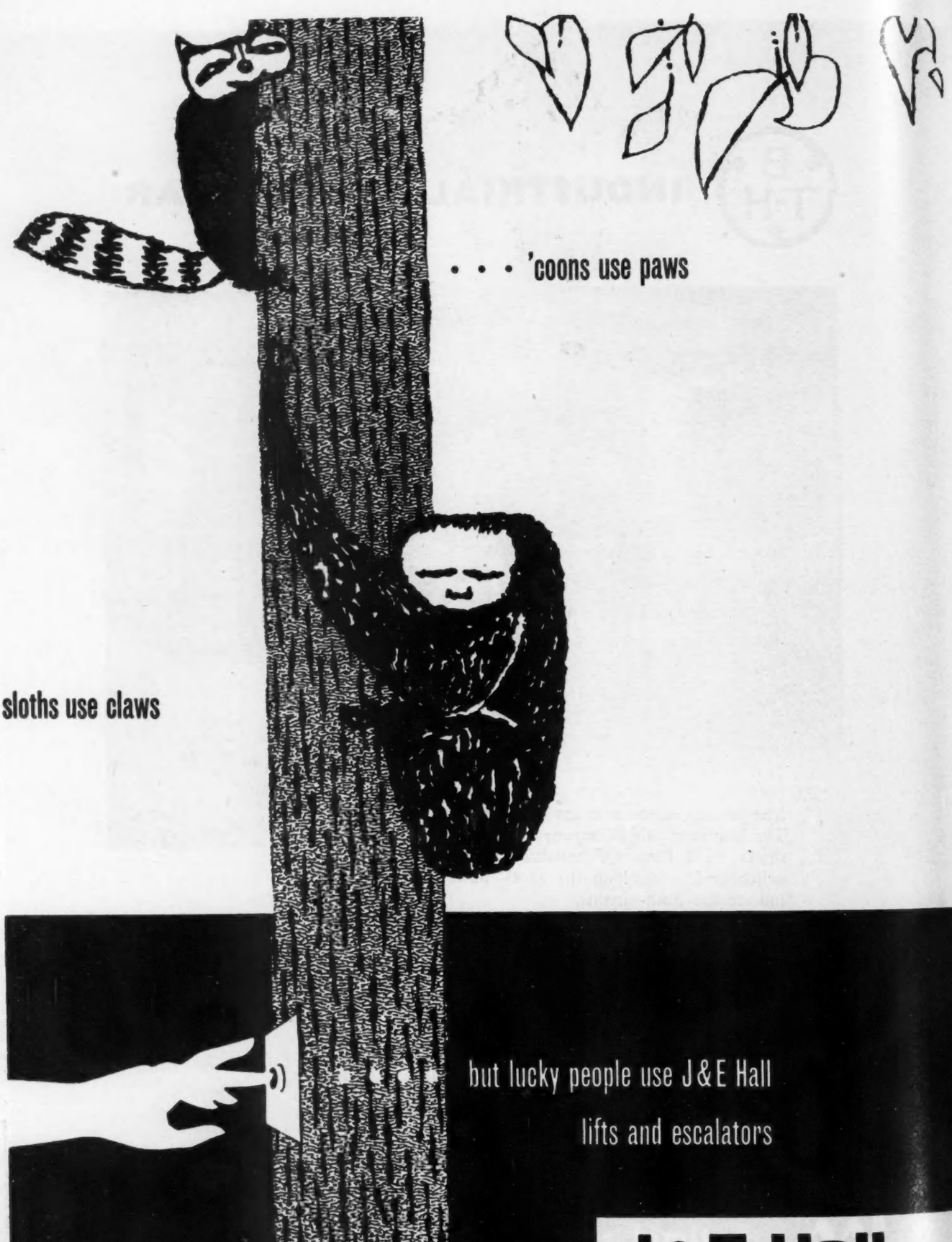
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but lucky people use J&E Hall
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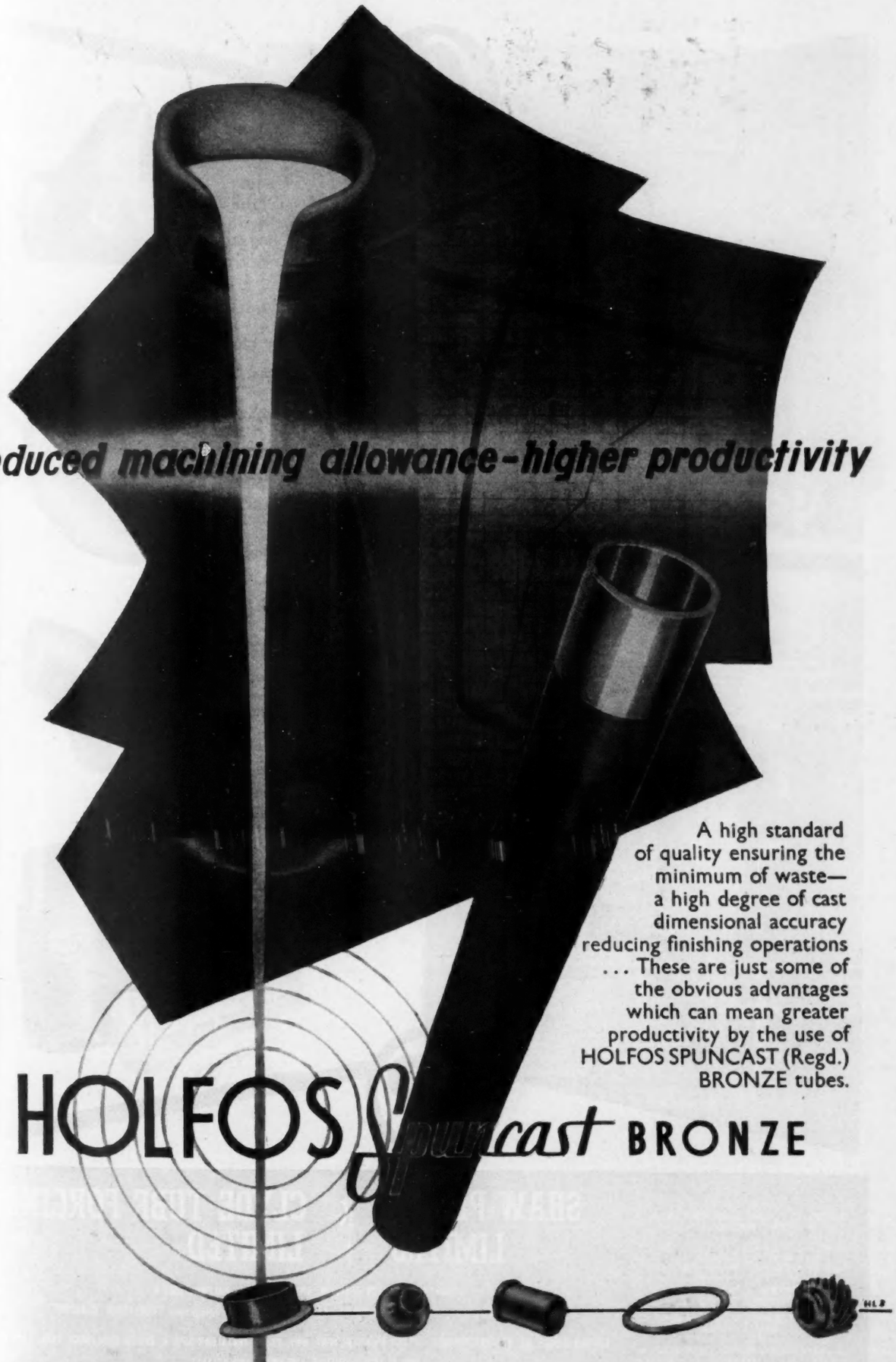

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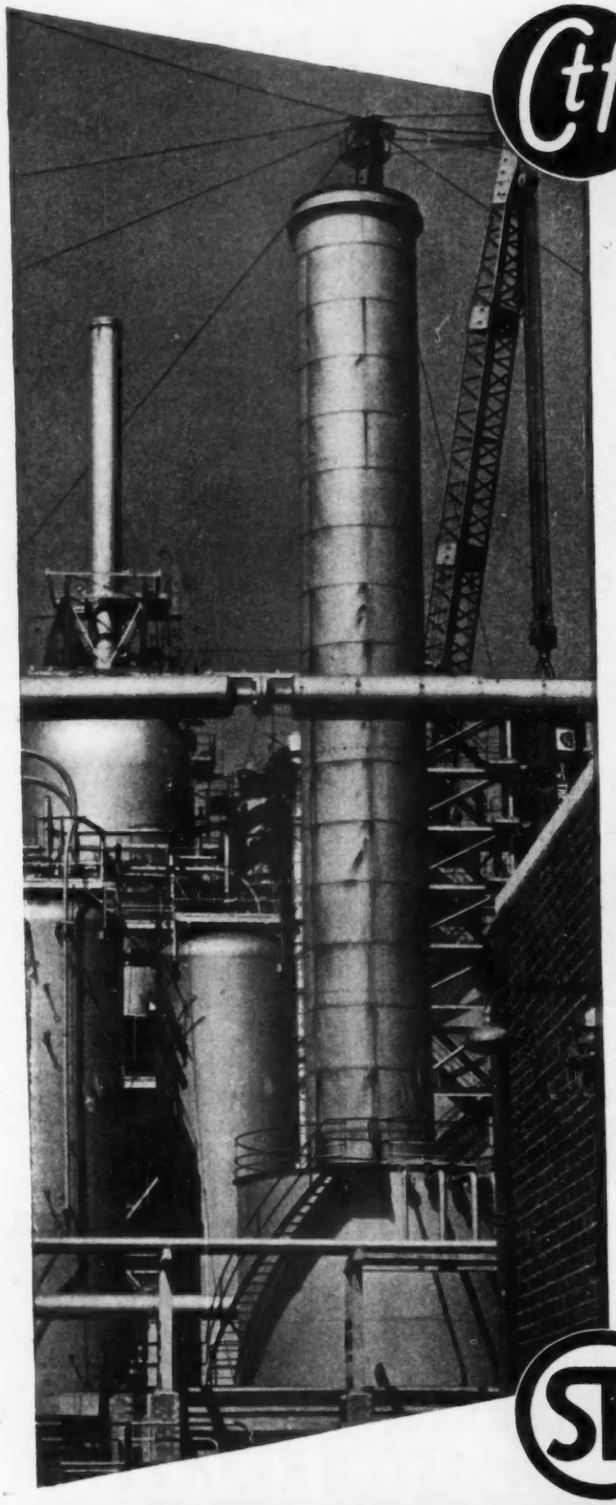

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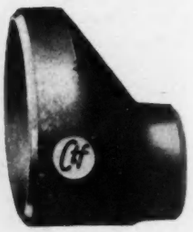

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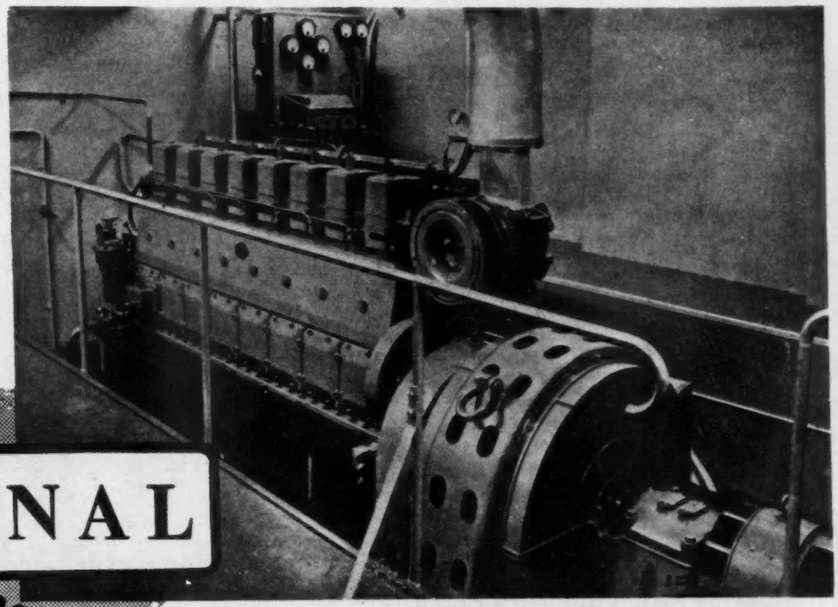

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provide *emergency* power and lighting for a well-known South African newspaper . . .

In the 'Cape Argus' newspaper printing plant, a National "R4AU8" type 660 b.h.p. pressure charged diesel engine drives a 500 kVA alternator for emergency supply.

Argus Building, Cape Town

Whatever happens, that daily miracle, the newspaper, must go to press! It is therefore especially important to guard against failure of electric supply. The National diesel engine is particularly suited for emergency use in these conditions, as it can be started up at very short notice and will provide power and lighting at economic cost.

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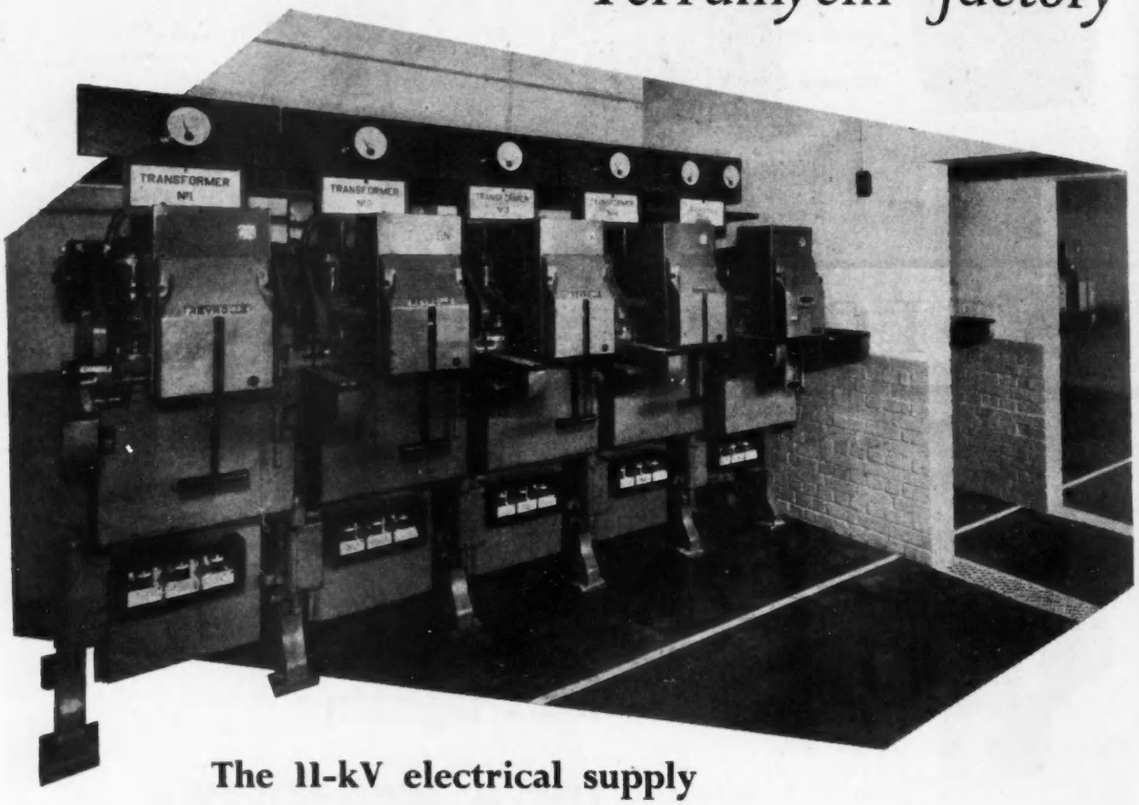
Electrical supply for a Terramycin factory



The 11-kV electrical supply for the new Richborough factory of Pfizer, Ltd. for the manufacture of the antibiotic drug Terramycin is controlled by Reyrolle type-C5T horizontal draw-out metalclad switchgear.

Reyrolle

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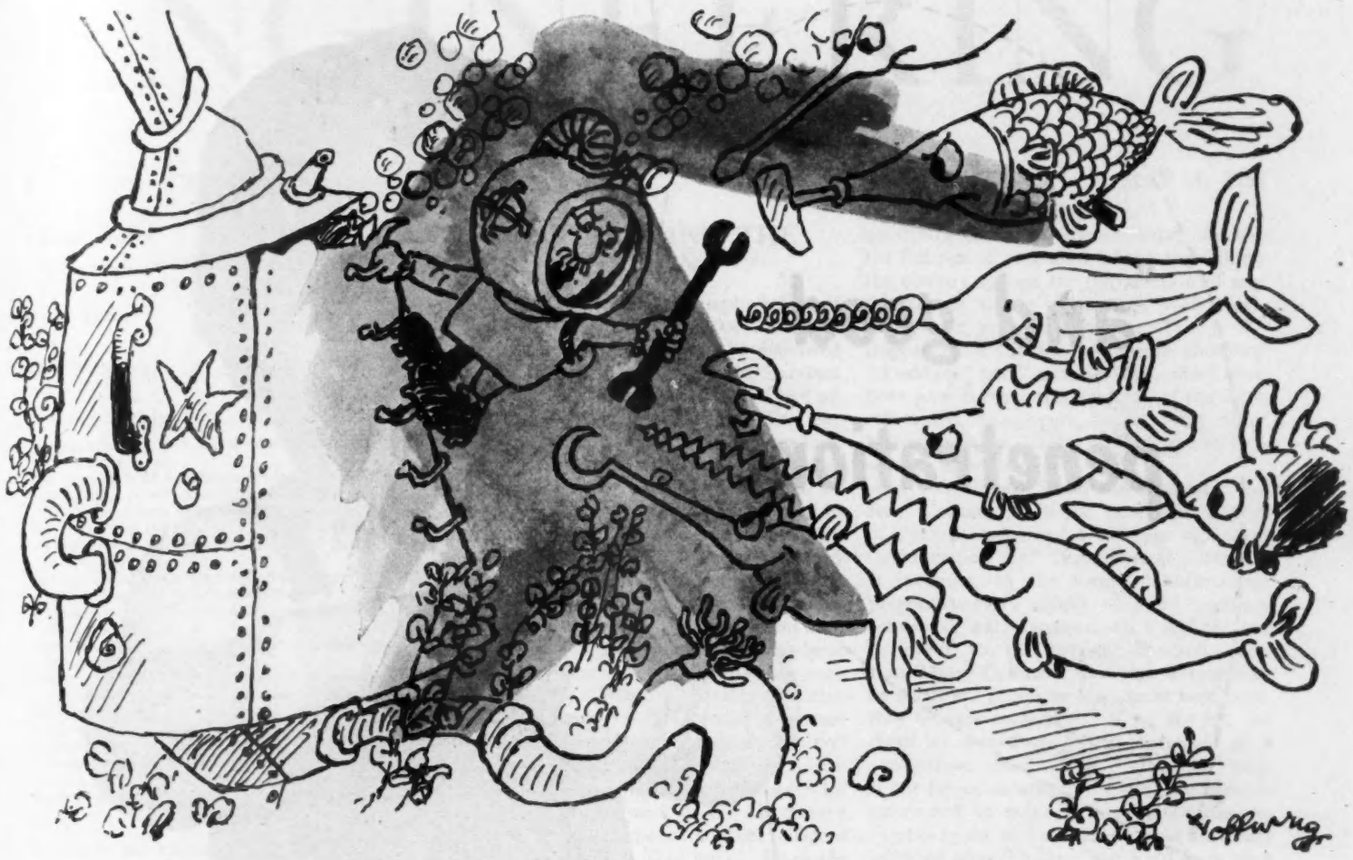

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ENGINEERING

An Illustrated Weekly Journal

Vol. 181 No. 4705 MAY 11, 1956

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COVENTRY AND THE NATION

A FORTNIGHT ago 11,000 employees went on strike because 3,000 of their number were told they would be dismissed during a major re-tooling of the Standard Motor Company's tractor factory. Not all of them were to be taken back. The fear of losing his job has become, in the worker's mind, identified with the introduction of automation and allied techniques. Never to be out of work is now so deep-rooted a need in post-war Britain that any sign of a break in the security of full employment tends to produce lightning reactions—almost invariably strikes. Redundancy, like differentials, has become a red rag to the trade-union bull. In both cases the appeal to strikers has been the same: to maintain positions already won.

Redundancy was already there in Coventry and Birmingham before automation became linked with it. The Standard Motors' announcement of re-tooling plans for a new tractor came shortly after workers had been put on a four-day week in the car factory because cars could not be sold in sufficient numbers to keep the plant busy. When the company made their plans to re-tool their plant some two years ago, the management fully expected to absorb most of the workers made redundant into their car plant.

It is not the first time that automatic transfer machines have been introduced by vehicle manufacturers and others in this country. Ford have done it on a comparable or bigger scale; so have Vauxhall and, nearer home, Austins. The issue is not about automation as such; it is about introducing machines which will replace men at a time and in a locality where there is already some unemployment and where short time is being worked. This unfortunate combination of circumstances has made everyone's position very difficult and fogged the basic issues.

The situation has burst upon the country as a whole with everyone unprepared for it. The economic committee of the Trades Union Council are studying the problem. The Government are still waiting for a detailed report on automation from the Department of Scientific and Industrial Research, which is expected to give a lead on how the human problems involved should be tackled. Meanwhile there is a general scurry to set up committees and study groups. The all-party Parliamentary and Scientific Committee of the House of Commons have set up a sub-committee "to consider—as a matter of urgency—the question of automation and its effect on the British economy." As the days pass, the strikers canvass for support—which they will almost certainly get from a good many sources—and influence the feelings of organised labour throughout the country against the introduction of any machine or device which does work previously done by human hands. This is the tragedy of the strike. Intemperate shouts of "Luddites" and "sack the lot", which have been seen in the correspondence of the more responsible newspapers, hardly assist either management or union leaders to reach a sensible solution.

In the United States last October, the Joint Committee on the Economic Report of Congress published a 600-page report on "Automation and Technological Change." It examines, in the form of testimonies, practically every aspect of every problem connected with automation. They are not irrelevant to the present situation. The Ford Motor Company said that automation or improved processes have to be used once they become available: "If we did not use them we would soon find ourselves at a competitive disadvantage." In their view it has helped to lighten the work, to make it safer, and to make it more interesting by increasing the skill content without adversely affecting employment. But Ford were then expanding rapidly.

Mr. Walter P. Reuther, the President of the Automobile Workers Union in the U.S., did not, in his testimony to the committee, attempt to minimise the problems of adjustment which arise—for the worker, for the company or, at times, for entire communities. He advocated careful planning and forethought, saying that the guaranteed annual wage negotiated by his union was a step designed to curb irresponsible action on the part of employers. The whole operation must be planned from the human standpoint even earlier than the new lay-outs. New skills have to be learned and re-training facilities provided, and—in Mr. Reuther's opinion—paid for by the employer, who has the responsibility of seeing his workers through the change without hardship: "The only sure way of making them socially responsible is to make them financially responsible for what they do or fail to do."

Some safeguard should obviously be provided against irresponsible action. But the main problem is to anticipate and to prepare for, in good time, the situations that may arise. Organised labour must be kept informed from the earliest stages by the management of the plant concerned. Rapid technological change makes it essential to have effective communications within the factories as well as nationally. Difficult problems can be tackled by both sides together. The benefits automation can bring are immense if it is properly handled. In the United States it is a major revolution,

and should not here be dismissed as something that will never come on a big scale, or as a "normal advance" in production techniques. It is not normal, it is revolutionary. It can perpetuate our prosperity. It can earn a new independence and power for Britain among the nations. The workers will understand this if they do not allow themselves to be blinded. Employers must, as always, carry the burden of the responsibility.

* * *

Plain Words

Beyond current disputes over the installation of automatic equipment in car factories lies the hard fact that if the motor industry fails to adopt all possible means of giving its customers the utmost value for money there will soon be no point in discussing how little work is to be done and by whom.

Many irrelevant reasons have been advanced to explain Britain's failure to hold her share of expanding overseas vehicle markets, but the essentials for success seem to be good service, a guaranteed supply of spares at a reasonable price, and meticulous attention to every detail in mechanism and equipment which can promote reliability and foster pride of ownership.

Without embarking upon odious comparisons, it is perhaps relevant to glance at the specification of a new German car announced last week and now selling at £800; the Mercedes-Benz 190. Its four-cylinder overhead-camshaft engine is equipped with a heat exchanger in the cooling system to stabilise oil temperature, an air filter on the dipstick orifice, and a hand ignition control. The transmission has synchromesh for all four speeds. Steering is by a recirculating ball system with hydraulic damper to eliminate road shock. The heater system, fitted as standard, has two separate ducts and matrices, with separate controls for driver and passenger. Adjustable outlets are provided to demist side windows as well as windscreen. All control knobs are in plated metal, designed *en suite* for this particular car. There is an anti-dazzle mirror, the steering wheel carries a full horn ring, which also works the direction indicators, and under it is a finger-tip trigger to flash the headlamps when overtaking. Markings on the speedometer indicate maximum permissible speeds in all gears. There is a choice of separate or bench-type front seats, with adjustable back-rests. Brakes have turbine cooling fins and self-adjusting shoes. External appearance is enlivened by chromium plating on gutters and window frames, and the fuel filler is lockable.

The challenge of such attention to detail at an economic price seems to be one of the greatest problems facing the industry, and one which management and labour can ignore only at their peril. But it should not be insuperable; the German car has its disappointments, including a rear suspension system which, though technically a delight, does not give riding comfort commensurate with the cost and complication involved.

THERMONUCLEAR FUSION

GAS DISCHARGE RESEARCH IN THE SOVIET UNION

By Academician I. V. Kurchatov

It is well known that the fusion of light elements to form heavier ones is likely to yield more energy than the fission of heavy elements, and it follows that if fusion reactions can conveniently be induced to take place, vast energy resources will become available. In addition, the fusion reaction has the advantages that radiation shielding problems are minimised and that its raw materials (hydrogen for example) are abundant. To initiate such a reaction, energy has to be supplied and one method of achieving this is by passing large pulsed electric currents through light gases in tubes. Research on this subject has been carried out in several countries including the United Kingdom and the Soviet Union, and we reprint here in slightly abridged form a paper "On the Possibility of Producing Thermonuclear Reactions in a Gas Discharge" recently delivered by the Soviet scientist, Academician I. V. Kurchatov, at Harwell. The prospects offered by confining the hydrogen-bomb reaction to a small volume, a cylinder for instance, are clearly immense.

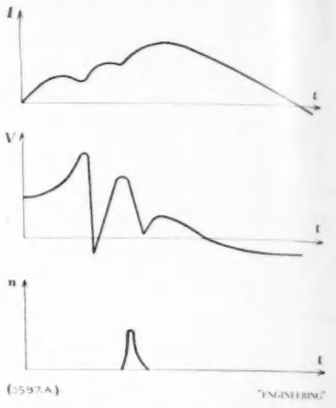

Fig. 1 Variation of current, voltage and neutron emission with time. The neutrons emitted proved, contrary to expectations, not to be thermonuclear in origin.

Among the more important problems of modern engineering science the utilisation of energy of thermonuclear reactions is a problem of foremost significance. Physicists over the whole world are attracted by this extraordinarily interesting and very difficult task of controlling thermonuclear reactions.

Investigations in this field are being carried out by Academician Artsimovich at our Institute. A leading role in the theoretical investigations was played by Academician M. A. Leontovich.

REACTION OF THE SUN

As is well known, thermonuclear reactions can arise if the temperature of matter is sufficiently high for atomic nuclei to surmount with appreciable probability the forces of the Coulomb barrier during thermal collisions. The excitation of thermonuclear reactions in deuterium or in a mixture of deuterium and tritium is especially interesting as in this case a noticeable effect should be obtained at relatively low temperatures. Physics is indebted to the founder of nuclear physics, Ernest Rutherford, for information regarding the interaction of deuterons. In one of his last investigations Rutherford studied the nuclear reactions which occur when two deuterons collide. It was difficult to suspect at that time that the new facts discovered by him would make more realistic our hope of mastering the energy sources which up to now have existed only in the hot remote parts of the sun and distant stars. The intensity of thermonuclear reactions in deuterium should greatly increase with temperature up to several billion degrees.

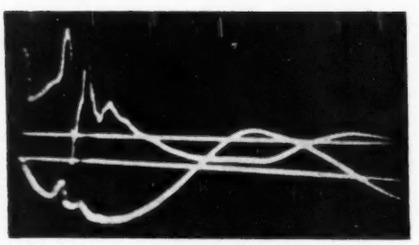

Fig. 2 Oscillogram of current and voltage for a discharge in deuterium at $V_0 = 40$ kV and $P_0 = 5 \times 10^{-2}$ mm. Hg.

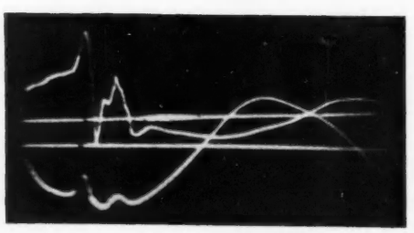

Fig. 3 Oscillogram of current and voltage for a discharge in deuterium at $V_0 = 40$ kV and $P_0 = 0{\cdot}2$ mm. Hg.

A notion regarding the conditions under which thermonuclear reactions should be experimentally observable can be obtained by considering some concrete cases. In deuterium, the density of which equals that of a solid body under normal conditions, a temperature of 2×10^5 deg. would be required to obtain one neutron per second per gramme of deuterium. If the deuterium were a highly rarified gas with a concentration of about 10^{23} atoms per cub. cm. a temperature of about 5×10^6 deg. would be required to produce some effect in a gramme of deuterium which would occupy a volume of 30,000 cubic metres. Thus, even to approach the threshold for production of thermonuclear processes the temperature of matter must be raised to a very high level. At such temperatures and under stationary conditions the deuterium should be an almost totally ionised plasma.

The amount of energy which must be concentrated in the plasma to raise its temperature to a level sufficient for the production of intense thermonuclear reactions should be comparatively small. Thus, the amount of thermal energy necessary to raise the temperature of one gramme of deuterium to 10^8 deg. equals only a few kilowatt hours. This is about the energy required to boil water in a family samovar. Therefore, if one were able to invent a method of heating the plasma with practically no thermal losses, even a low-power energy source could be used to induce intense thermonuclear processes. The main problem is to exclude heat losses which rapidly increase with the temperature since the thermal conductivity of the plasma is proportional to $T^{5/2}$. When matter is heated to a temperature of only several tens of thousand degrees the losses in the absence of thermal insulation will be so great that further increase of temperature will be practically impossible.

There is another obstacle which arises when dense substances are heated: the enormous mechanical forces which result from increase of pressure with temperature must be overcome. On heating initially solid or liquid deuterium we find that already at $T = 10^5$ deg. the pressure exceeds a million atmospheres. Therefore, thermonuclear reactions can be induced only during a very short period of time in dense substances, and such a process will always resemble an explosion (which, however, may not be dangerous) or a brief pulse.

There are quite a number of directions which may be followed in attempting to solve the problem of generating intense controllable thermonuclear processes. On the one hand there are the approaches which lead to stationary thermonuclear reactions and on the other, those which are based on the idea of utilising an instantaneous temperature rise in transient processes of very brief duration. However, irrespective of the way the investigation is carried out there is one problem that is inevitably encountered, namely, the isolation of the plasma heated to a high temperature from the walls of the vessel in which it is confined. In other words, a means must be found to keep the fast particles within the plasma long enough for the particles to have a good chance to react together.

INSULATION BY MAGNETIC FIELD

One of the ideas proposed in connection with this problem is that of using a magnetic field for thermal insulation of the plasma. Academician Sakharov and Academician Tamm were the first to point out this possibility in 1950. In a sufficiently strong magnetic field electrons and ions can freely move only along the lines of force. In a plane normal to the lines of force the particles will move along circles of small radius. The positions of the centres of these circles can vary only as a result of collisions, each collision displacing the centre by a distance of the same order of magnitude as the radius of curvature of the particle trajectory. If the radius of curvature of the trajectory is small compared with the mean free path, diffusion of the particles and thermal conductivity of the plasma in the plane normal to the magnetic field will be greatly diminished. The theory of processes taking place in completely ionised plasma indicates that at high field strengths, H, and high temperatures the transverse thermal conductivity coefficient is inversely proportional to H^2 and decreases by many orders of magnitude with respect to the value found in the absence of a magnetic field. Under these conditions, however, radiation losses must be taken into account.

The magnetic field required to provide the thermal insulation may be produced by passing a sufficiently intense current through the plasma. The current will also heat the plasma as a result of Joule losses and of the work of electrodynamic forces. These considerations were the basis for carrying out theoretical and experimental studies of the physical processes which occur in a plasma on passage of intense currents.

We shall first examine the principal theoretical concepts which preceded the experimental work. When a current is passed through a plasma the latter should contract under the action of electro dynamic forces (attraction of parallel currents). An increase of plasma temperature should follow. If a contracted column of the plasma is detached from the vessel wall as a result of electrodynamic contraction ("pinch" effect) its temperature may be estimated from the condition that the pressure of the ionised gas is balanced by the electrodynamic forces. A simple computation shows that in such quasi-stationary contraction processes the plasma temperature should be proportional to the square of the current. As is well known, if the electrons and ions are in thermal equilibrium the plasma temperature can be expressed by the equation:

$$T = \frac{I^2}{4Nk}$$

Here I is the current expressed in electromagnetic units, N is the number of particles of a given sign per centimetre length of discharge tube and k is the Boltzmann constant. Investigation of the conditions of thermal equilibrium showed that for $N \sim 10^{15}$ the electron and ion temperature should be practically identical. At appreciably lower values of N only the electron temperature will increase.

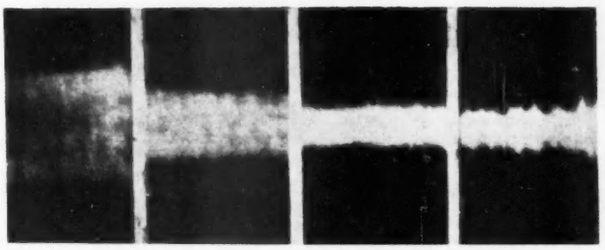

Fig. 4 Four successive frames of a moving picture of a pulsed discharge in deuterium taken at 0·5 microsecond intervals. The column of gas is held clear of the tube walls by an electromagnetic field but this can only be effective while the current is growing.

NO CONTINUOUS PROCESS

A contracted plasma column detached from the walls can exist only as long as the current is building up. If the current is constant the column will disintegrate and come in contact with the walls. It is evident that a thermonuclear reaction with a constant yield over an appreciable period of time cannot be produced by passing a current through a plasma. In principle it should be feasible to heat the plasma periodically and induce thermonuclear reactions in phase with the peak current. Calculation of the expected thermonuclear effect led to the following result which at first glance may seem paradoxical. It was found that during a single heating the total number of elementary nuclear-interaction acts pertaining to a given value of the peak current should be independent of the duration of this cycle. Thus, it seemed that it should be possible to excite very intense thermonuclear reactions by sending pulsed discharges of very short duration through deuterium on the condition that the current was sufficiently large. Theoretical calculations indicated that already a current of 300 kA should be sufficient to produce an appreciable emission of neutrons of thermonuclear origin. At currents of several million amperes the emission should be very intense. Such were the theoretical predictions which preceded the experimental work.

Further development of the conceptions regarding the nature of the processes occurring in a plasma during the passage of an intense current was profoundly influenced by the new facts discovered during experimental investigation of powerful pulsed discharges. These results completely altered the landscape and colours of the picture created by the first spurts of theoretical effort.

Experimental investigation of intense pulsed discharges was carried out in a broad range of the parameters characterising the initial discharge conditions.*

RANGE OF CONDITIONS

Discharges through hydrogen, deuterium, helium, argon, xenon and gas mixtures (deuterium-helium, deuterium-argon, deuterium-xenon) of various relative content were studied. The measurements were carried out at gas pressures ranging from 0·005 mm. Hg to one atmosphere. Most of the experiments were performed with straight discharge tubes. The length of the discharge gap varied from several centimetres up to two metres and the diameter from 5 to 60 cm. The discharge was produced by a voltage of several tens of kilovolts. The peak current varied from 100 kA up to two million amperes, the rate of build-up of the current lying between 10^{10} A/sec. and 10^{12} A/sec. The maximum instantaneous power released in the plasma in these experiments attained as much as 40 million kilowatts.

Banks of high-voltage condensers were used to produce the discharges. The leads which carried the current from the condenser to the discharge gap were designed in such a manner as to keep the parasitic inductance of the electric circuit down to minimum, since this factor restricted the magnitude of the current and its rate of growth. For a voltage of 50 kV and total capacity of the condenser bank of several hundred μF the parasitic inductance of the circuit and switch was only 0·02 to 0·03 microhenry (in those cases when the current growth was maximal.)

Oscillographic methods of measurement of the main parameters characterising the state of the plasma during passage of a current were developed, and these were used to study the intense pulsed discharges. Besides oscillography, ultra-high-speed moving picture cameras (up to 2 million frames per second) were used as well as photography by aid of Kerr cells supplied with special electro-explosive types of shutters.

In addition to the discharge current and voltage, oscillograph records were also made of the intensity of separate spectral lines from the plasma, of the neutron and X-ray intensity, of the magnitude of pressure pulses measured with aid of piezoelectric elements and also of the instantaneous magnitude of the magnetic and electric field strengths at various points within the plasma. The magnetic and electric fields were measured with small probes in the form of miniature coils, loops or needle electrodes of various shapes which could be placed at various points within the discharge vessel.

Space limitations do not permit me to give a detailed account of the numerous results obtained in this series of experiments and I will therefore report only a small part of the available experimental material.

* In England pulsed discharges in gases have recently been investigated by J. D. Kraggs and his collaborators, S. W. Cousins and A. A. Ware, and others.

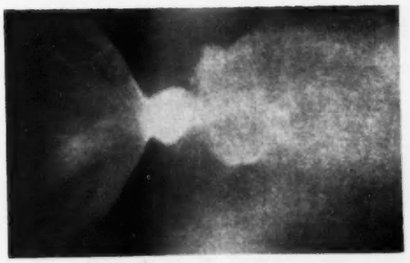

Fig. 5 Photographic sweep of a discharge in deuterium at a pressure P_0 = 10 mm. Hg. Distance between hemi-spherical electrodes 45 mm. Scale of sweep : 1 microsec. = 18 mm. I_{max} = 1·2 × 10^6 amperes. T/4 = 9·5 microsecs. Diameter of chamber 180 mm.

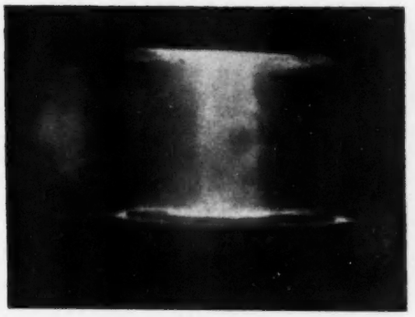

Fig. 6 Moment of contraction of the discharge column in vessel of 180 mm. diameter (photograph by Kerr cell).

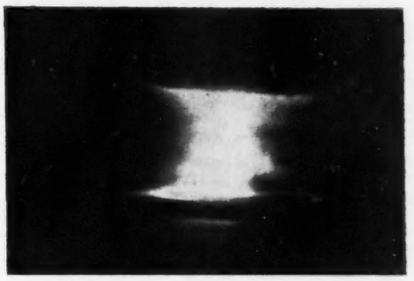

Fig. 7 Kerr cell photograph 2·2 microsecs. after commencement of discharge in deuterium. For Figs. 6 and 7 : P_0 = 1 mm. Hg., exposure 0·2 microsec, electrodes 45 and 40 mm. apart respectively.

CURRENT AND VOLTAGE CHANGES

Of greatest interest is the first phase of the discharge during which the plasma current rises from zero to the peak value. On the experiments discussed here this phase lasted from 3 to 30 microseconds. At the beginning of the discharge after breakdown of the gas a smooth increase of the current and voltage in the discharge gap takes place. After a certain period of time a sharp decrease of the voltage occurs. At the same time a more or less pronounced kink can be seen on the current oscillogram (see Fig. 1, which illustrates the general nature of time variation of the current and voltage, and also the oscillograms in Figs. 2 and 3). After the first drop the voltage began to increase rapidly and then sharply dropped again. This second voltage decrease was paralleled by the appearance of a new kink on the current oscillogram. In some cases three consecutive sharp changes in the otherwise smooth variation of the current and voltage was observed at the first stage of the discharge. These characteristic features of high current pulsed discharges are especially pronounced when the discharge takes place in gases of low atomic weight (hydrogen, deuterium, helium) and at low initial pressures.

When the rate of current build-up is of the order of 10^{11} A/sec. the interval between breakdown of the gas and appearance of the first voltage drop comprises several microseconds. This time interval is a regular function of the parameters characterising the initial conditions of the discharge. For a given discharge tube diameter it varies approximately as the fourth root of the gas mass per centimetre length of the discharge gap.

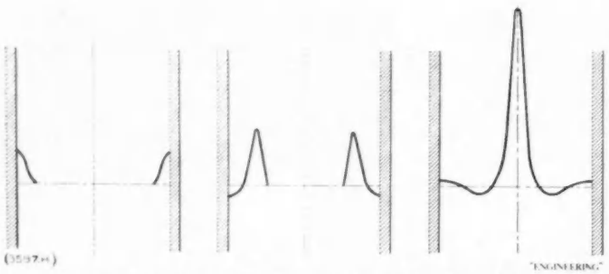

Fig. 8 Current density distribution over the cross-section of the discharge tube. From left to right: first stage of discharge; moment when current moves towards axis; after the first contraction.

The inductive resistance is much larger than the ohmic one in pulsed discharges in which the current increases at a high rate. Thus, by using current and voltage oscillograms one may find the time dependence of the inductance of the plasma column and hence determine how the radius of the column changes at various stages of the process. An analysis of this type indicates that in all cases the very first stage of the process is featured by an increase of the inductance due to contraction of the plasma towards the discharge tube axis. The speed of constriction of the plasma increases with the initial current build-up rate $\left(\text{that is, with the derivative } \frac{dI}{dt}\right)$ and decreases with the gas density. At the moment when the kink on the current oscillogram appears and a sharp drop in the potential is observed the inductance begins to decrease. This means that this moment corresponds to maximum contraction of the plasma filament. This situation is followed by a rapid expansion of the plasma filament. The appearance of several kinks on the current oscillogram signifies that consecutive contractions and expansions of the column take place.

These conclusions, which were obtained by analysing current and voltage oscillograms, are confirmed by data obtained by applying ultra-high speed cinema photography of pulsed discharges in tubes with transparent walls. In Fig. 4 are shown four successive frames of a moving picture of a pulsed discharge in deuterium at a pressure of 0·1 mm. Hg. and peak current of about 200 kA. These pictures were taken at intervals of 0·5 microsecond and refer to only a very small period of development of the process which corresponds to the current and voltage break. The minimum plasma column diameter corresponds exactly to this moment (the moving picture frames were phased with the current and voltage oscillograms).

PLASMA COLUMN PHOTOGRAPHED

The photograph reproduced in Fig. 5 was obtained by using a moving picture camera for continuous photography. In this method a narrow slit perpendicular to the axis of the discharge tube subtends a small segment of the discharge gap the image of which is swept across the film at high speed. As a result, a continuous picture of variation in the diameter of a small segment of the plasma column was obtained on the film. The photograph shown here was obtained for a discharge in deuterium with a peak current of about one million amperes. The initial gas pressure was 10 mm. Hg. The moment of maximum contraction and the further development of the process are clearly visible.

A photograph of the contracting plasma column obtained with the aid of a Kerr cell is shown in Fig. 6. Valuable data on the main physical processes occurring in intense pulsed discharges can be obtained by measuring the magnetic and electric field strengths in plasma. Magnetic field measurements permit the following picture of current distribution in the plasma to be drawn. Directly after breakdown, the current conducting region is a thin cylindrical layer adjacent to the discharge tube walls. The inner boundary of this layer at first slowly and then more rapidly moves towards the axis. After a certain interval of time the current fills the whole tube as a result of movement of the inner current boundary. The moment at which the current reaches the axis practically coincides with the time of appearance of the first kink on the oscillogram.

The current density near the discharge axis at this time exceeds the mean current density over the cross-section of the tube by several dozens of times. On subsequent expansions and constrictions the current density remains very high in a central region of several centimeters in diameter although appreciable fluctuations are observed.

The current density distribution over the cross-section of the discharge tube at various periods of time is shown schematically in Fig. 8. The current density distribution at the very first stage of the discharge is shown in the figure on the left. The second one refers to the moment when the current was moving towards the axis. The distribution after the first contraction of the plasma column is illustrated in the right figure. An interesting feature of this stage of the process is that in a certain zone of the discharge the current reverses its direction.

The velocity of the ionised gas is the quantity which directly characterises the dynamics of a pulsed discharge. In a plasma of sufficiently high conductivity this velocity is determined by the ratio between the longitudinal electric field strength E and the magnetic field strength H:

$$v = \frac{cE}{H}$$

Measurements of E and H indicate that in a pulsed discharge with rapid growth of current the radial velocity of the plasma may be very high. In the experiments described here, the maximal velocity during contraction and expansion of the plasma column in rarefied gases was found to reach hundreds of kilometres per second. This signifies that the kinetic energy of the drift of the plasma ions is of the order of several hundred electronvolts.

NEUTRON EMISSION

One of the most interesting effects observed in intense pulsed discharge in light gases is the appearance of penetrating radiations. In 1952, soon after experiments with pulsed discharges were started it was found that at sufficiently high currents the discharge in deuterium becomes a source of neutrons. The first experiments performed with the aim of studying this phenomenon showed that the neutrons appear under conditions when the peak discharge current is 400 to 500 kA and the initial deuterium pressure is about 0·1 mm. Hg. The neutron emission was observed in a relatively narrow pressure range and its intensity rapidly increased with increase of the applied voltage, i.e., with increase of the peak current. In these first experiments the radioactivity induced in a silver target embedded in a paraffin block placed near the discharge tube served as the neutron detector. A possible explanation of this phenomenon was that the neutron emission resulted exclusively from collisions between the accelerated deuterons and deuterium adsorbed by the electrodes on tube walls; control experiments, however, did not confirm this explanation.

At the early stages of investigation it was quite natural to assume that the neutrons resulted from thermonuclear reactions in the plasma heated to a high temperature. This was exactly what was expected from the beginning and the fact that the effect was detected under conditions which completely corresponded to the *a priori* theoretical predictions seemed to speak in favour of this viewpoint. The behaviour of the neutron radiation (its dependence on pressure and current) observed in the first experiments qualitatively concorded with the assumption that the phenomenon was due to a thermonuclear mechanism.

However, very soon serious doubt concerning the correctness of this assumption began to appear. This happened after it was found that neutrons can be observed at comparatively small discharge currents, of the order of 150 kA. According to the initial calculations the intensity of the thermonuclear reaction at currents of 30 kA should be practically zero.

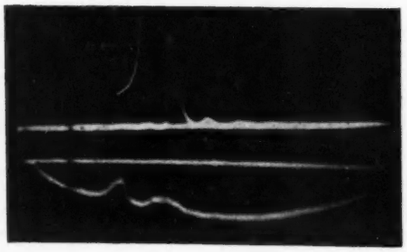

Fig. 9 Oscillogram of current and neutron pulse for a discharge in deuterium at $V_0 = 40$ kV and $P_0 = 5 \times 10^{-2}$ mm. Hg.

NO EVIDENCE OF FUSION REACTION

In subsequent experiments the neutrons were recorded by a scintillation counter fed to an oscillograph. This technique made it possible to find the relation between the discharge properties and the moment of appearance of neutrons. It was found that the neutrons were always emitted when the second kink appeared on the current oscillogram, i.e., at the moment when the plasma was subjected to the second contraction (Fig. 9). No neutrons were produced during the first contraction. The neutrons were always emitted as short pulses with a steep front. The rise time of the pulses was several tens of microseconds. The chief results of the oscillographic investigations were not consistent with the initial assumption that the neutron emission is the result of quasi-stationary heating of the plasma during which the temperature increases proportionally to the square of the current.

Further investigation yielded new interesting facts pertaining to the plasma neutron radiation. It was established, in particular, that in specially designed discharge tubes the neutrons could appear at fairly high deuterium densities, as much as several tens of millimeters of initial pressure. This fact signified that the neutron emission was certainly not a trivial effect. It was found that not only neutrons but hard X-rays as well were produced in pulsed discharges. Penetrating X-rays were found when large currents were passed through hydrogen, deuterium and helium. The radiation produced by discharges in deuterium always consisted of short spurts. The pulses due to the neutrons and X-ray quanta always appeared simultaneously on the oscillograms. The energy of the X-ray quanta produced in pulsed electrical processes in hydrogen and deuterium reached 300-400 keV. It is noteworthy that at the time of emission of such high energy quanta the voltage applied to the discharge tube was only about 10 kV.

Theoretical analysis of the complex phenomena which occur in the plasma of a pulsed discharge oscillating under the action of electrodynamic forces is still at such a stage that quite a number of facts remain to be explained. However, the general picture of the process is gradually becoming clear and some of the peculiarities of the phenomenon seem to have been sufficiently elucidated. It is not evident that contraction and expansion of the plasma are not quasi-stationary processes characterised by equilibrium between the external and internal pressures.

CYLINDRICAL SHOCK WAVE

In the equations describing the dynamic of a pulsed discharge the main term is that which accounts for momentum changes in the ionised gas due to magnetic pressure. The kinetic energy of the ordered motion should at some stages of the process therefore greatly exceed the thermal energy concentrated in the plasma. At the initial stage of the discharge the internal pressure in the plasma is very small and the electrodynamic forces therefore produce acceleration along the radius towards the discharge tube axis. Thus, the work of the electrodynamic forces is not expended in raising the temperature but in imparting kinetic energy to the converging plasma layer. At this stage the discharge tube operates as a peculiar type of accelerator in which the particles are driven by the magnetic field. Since charged particles, irrespective of sign, will move with the same velocity, the kinetic energy acquired by the ions will be quite large whereas the kinetic energy of the electrons will practically not change in virtue of the small mass of these particles. From the viewpoint of gas dynamics the contraction process should be considered as a phenomenon in which a cylindrical shock wave converging towards the axis is produced in the plasma. At first, the gas located before the inner wave front is not ionised. When the wave begins to move the gas is carried along together with the charged particles of the plasma and its atoms simultaneously become ionised. The amount of matter which begins to move gradually increases and the total amount of ions and electrons in the plasma rapidly increases. The duration of the contraction phase can be determined by calculating the velocity acquired by the contracting gas. It was found to be approximately proportional to $\sqrt[4]{\frac{M}{V_0^2}}$ where M is the mass of gas per unit length of discharge tube and V_0 is the initial voltage. This is exactly what one finds experimentally for the interval between breakdown and appearance of the first kink in the current oscillogram.

SUCCESSIVE GAS CONTRACTING

The final stage of cumulative contraction sets in when the plasma accelerated by the magnetic field reaches the axis. At this moment a great part of the

energy is ordered motion changes into heat and the pressure plasma temperature sharply increase. During maximum contraction the plasma temperature may be of the order of one million degrees. The nature of the processes occurring during maximum contraction is not very clear but apparently after maximum cumulation a diverging shock wave should appear which drives the plasma towards the walls. Inside the outgoing wave there should be a rarified zone. Under the action of electrodynamic forces which tend to compress the current the outgoing wave should be abruptly decelerated and a new phase of contraction should ensue. This stage differs from the first in that the density in the inner region of the discharge is small and the gas in this region is probably almost completely ionised. As a result, during the second contraction conditions are produced which are favourable for acceleration in the longitudinal electric field of a certain group of ions and electrons located near the discharge axis, i.e., in the region in which the magnetic field is small. One may note here a certain analogy with the accelerating mechanism proposed by Fermi in his theory of origin of cosmic rays. A plasma of high conductivity will move together with its magnetic field and with respect to particles located in the inner zone it will be equivalent to a converging magnetic wall from which the enclosed electrons and ions will repeatedly be reflected, their energy increasing after each reflection. Acceleration of ions and electrons in the longitudinal electrical field near the discharge axis is possibly the explanation of the appearance of neutrons and penetrating X-rays. The electric field strength during the second contraction may be very high. It may exceed the instantaneous external voltage applied to the discharge tube by many times.

However, it must be mentioned that not all in this acceleration mechanism is yet clear. Under certain conditions acceleration of ions in a longitudinal electric field may also be possible outside the central zone of the discharge due to the presence of space charges. Some types of instability which are peculiar to the column may play an important role in accelerating particles in the plasma. In particular, one type of instability observed experimentally may be of importance for acceleration of electrons. It consists of spontaneous creation of a longitudinal magnetic field in the plasma as a result of spiralling of the plasma column.

THREE OSCILLATIONS ONLY

If the second contraction is followed by a few more oscillations of the plasma column, the acceleration of the particles may be repeated several times. Experimentally not more than three successive oscillations have been observed. A possible explanation of this is that the plasma may begin to interact with the discharge tube walls with the result that the wall material begins to evaporate and appreciable amounts of foreign gases appear in the volume.

We considered here some features of the phenomena which accompany the passage of intense pulsed discharges through rarified gases. The success of further work in this direction will greatly depend on the possibility of creating conditions under which the plasma column will experience multiple oscillations during build-up of the current without coming into contact with the walls. However, there are serious reasons to believe that this cannot be achieved.

On appraising the various approaches to the problem of obtaining intense thermonuclear reactions we do not deem it possible completely to exclude further attempts to attain this goal by using pulsed discharges. However, other possibilities must also be carefully considered. Especially interesting are those in which the idea of stationary processes may be used.

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Letters to the Editor

FREE-PISTON GAS GENERATOR

SIR,—As one who is keenly interested in the possible application of the Pescara free-piston gas generator in this country for marine purposes, I feel I must comment on your editorial note "A Competitor for the Gas Turbine?" which appears on page 199 in your issue of April 13.

While there is a great deal that is informative and stimulating in this editorial note, there are one or two facts which—if my interpretation of the characteristics of this "machine" is correct—seem to be in need of elucidation. Your note gives a somewhat misleading impression and is technically incorrect.

According to the note "the purpose of the gasifier is to produce a large quantity of gas under high pressure" and "the gasifier takes the place of the combustion chamber of a gas turbine set and delivers gas at pressures up to about 1,000 lbs. a sq. inch." As I understand it, one of the advantages of the free-piston gas generator/turbine engine system is that it produces its power gas at moderate temperatures and pressures. In addition there is the point that it does not take the place of the combustion chamber of the gas turbine, but of the combustion chamber and of the associated gas turbine and air compressor required to produce the power gas element which finally provides the net shaft power output.

In some respects the free-piston gasifier corresponds to the boiler of a steam turbine set, except again for the fact that temperatures and pressures are far lower than those with the other prime mover.

I shall be glad if you could find space in your columns to correct the erroneous impression that you have given.

Yours faithfully,
"M.I.Mar.E."

April 30, 1956.

[*Editor's Note*: We thank our correspondent for pointing out the implied error in the Weekly Survey note. The note stated, however, that the gas was produced at 1,000 lb. per sq. in. and this is, in fact, the case. The fall in pressure occurs at the receiver, so that the gas is actually delivered to the turbine at about 45 lb. per sq. in.]

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Obituary

Dr. S. WHITEHEAD
An Outstanding Research Man

The sudden death of Dr. S. Whitehead, which occurred on May 5 at Hampton-on-Thames at the early age of 53, deprives electrical research of an outstanding personality. During the last ten years, as Director of the British Electrical and Allied Industries Research Association, he had played a leading part in supervising investigations in many important fields and had proved himself to be an able administrator. If on first acquaintance he seemed to be a typical "back room boy" a closer contact showed that he possessed other qualities which contributed to his undoubted success in a wide sphere of activity.

Stanley Whitehead was born at Sutton, Surrey, on July 27, 1902, and was educated at Sir Walter St. John's School and Oxford University, where he obtained his first degree in 1924 and became a Doctor of Philosophy in 1933. During the following year he was engaged on investigations into thermionics at the Clarendon Laboratory, and then began his long connection with the British Electrical and Allied Industries Research Association, which he joined as a technical assistant in 1925. He subsequently became responsible to the Director for all the laboratory work, except that connected with control apparatus and surge phenomena, but including many investigations into dielectric phenomena, and was outstanding for the way in which he bridged the gap between physics and electrical engineering. He was appointed assistant director in 1939 and Director in 1946, on the retirement of Mr. E. B. Wedmore, a position he was holding at the time of his death.

Dr. Whitehead was elected an associate member of the Institution of Electrical Engineers in 1929, and was transferred to the class of member in 1940. He was chairman of the Measurements Section in 1948–49. He had been vice-president, honorary treasurer and chairman of the London Branch of the Institute of Physics, as well as chairman of the Committee of Directors of Research Associations.

He was the author or part author of about 30 important papers, and of text-books on "Dielectric Breakdown of Solids" and "Dielectric Phenomena. He had also written on interference with radio and telephone communication circuits, as well as on the heating of cables.

Weekly Survey

Cover Picture: *We have shown in previous cover pictures various stages in the manufacture of seamless steel cylinders intended for the storage and transport of oxygen, air and other gases under high pressures. This week one of the final operations is depicted, namely that of hot forging the neck of a high-pressure air cylinder in a hydraulic press.*

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Iron and Steel Plans and Prices

Two decisions reached last week by the steel industry—to increase capacity and to raise prices—are of the utmost importance to the country. Steel has been sold more cheaply to users in Britain than to any of their competitors almost anywhere else in the world, and it is a big advantage to jeopardise. But not enough has been produced. For ten years the expansion of the steel industry has lagged behind the expansion of steel-using industries. As a result, last year over half a million tons of sheet and tinplate had to be imported, 82 per cent. from the United States. The question of more rapid expansion has often been raised, but never very satisfactorily answered. In general, the iron and steel industry found that their estimates of demand, which they project over a 3-to-5-year period, were lower than the estimates of requirements put forward by using industries. Rising imports over the past three years show that this policy of slow, almost reluctant, expansion was mistaken, and very much amiss from an industry owned by the State and supposedly run for the benefit of the British economy.

Now that the steel companies are once more able to make their own decisions—this much could be expected from denationalisation—it may be that a different attitude to the future will emerge and that planning will be on a 10-to-30-year, instead of a 3-to-5-year term. But there is a close link between price levels and expansion. Higher profit margins make possible, and more practicable, a bolder policy. The logical next move would be to do away with the price equalisation mechanism: why should the efficient companies pay from their profit margins for the less efficient ones? The steel-using industries' long-term interests lie in virile and up-to-date iron and steel suppliers, who may well be able to expand output sufficiently quickly to absorb rising costs.

The Steel Company of Wales's third major expansion plan, which is discussed in the following note, is the kind of tonic British engineering needs, but is the dose large enough? Ingot production at the Abbey Works in South Wales will be increased from 2·4 million tons at the end of 1956 (production in 1955 was 1,748,000 tons) to 3·0 million tons in 1960. This is expected to increase the company's output of sheet and tinplate by approximately 435,000 tons a year "to assist in meeting the expected increase in demand for flat rolled products in 1960." Though very large, this scheduled increase is less than imports in 1955. There would appear to be little if any allowance for a growth in exports, where British steel is very competitive. Yet this is the largest and in many ways the most efficient unit in the industry. British steel manufacturers still have a long way to go before they are in a position to meet all calls likely to be made upon them.

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Expansion at Abbey Works

The Steel Company of Wales plan to spend £48 million in four years to install additional capacity for 435,000 tons of rolled products a year. The Iron and Steel Board's approval had long been expected, and contracts have already been placed. Sir Robert McAlpine have been given the civil engineering contract, worth £7 million. The British Oxygen Company are to build, at the cost of £1 million, two oxygen

plants with a combined output of 300 tons a day to feed the three new 50 ton Bessemer converters which will produce all the additional steel ingots required.

The complete scheme, which is to provide employment for an additional 3,000 people (the company already employ over 20,000 on steel production and nearly 6,000 on construction work) is based mainly on imported iron ore. Port Talbot docks are in a position to handle the necessary 3½ million tons a year without difficulty. Limestone is available in the company's own quarries. A new coal washery with an output of 250 tons per hour will be erected. Another 80 coke ovens will be installed, bringing the total number in the works to 310. A fifth blast furnace of 10,000 tons a week will quadruple pig-iron production. The Bessemer converters will tend to reduce the overall cost of the blast furnace burden, since both capital cost and operating costs are lower.

The increase in rolling mill capacity is planned to ensure a minimum of interference with output. The existing slabbing mill will be converted into a universal mill by the addition of vertical rolls. This will be the only item of plant to be shut down, though only for 15 days. It will then have the capacity to roll 60,000 tons of ingots a week. The 80 in. continuous hot strip mill is adequate to roll the 50,000 tons a week of hot strip which will be required, and the only new mill projected is a 56 in. four-stand cold reduction mill to process thin sheets for sale as galvanised or black sheets, or for processing as tinplates. Tinplate capacity at the new Velindre Works (now approaching completion) will be expanded by the addition of an electrolytic tinning line.

Thus the giant of the British steel industry will rise further above the rest. Last year the Steel Company of Wales accounted for 9 per cent. of total steel output in the United Kingdom, compared with 2·8 per cent. in 1948. By 1960, over £145 million will have been spent on increased capacity since the company was formed, in 1947, to take over certain works from Richard Thomas & Baldwins, Guest Keen Baldwins Iron and Steel Company, John Lysaght and Llanelly Associated Tinplate. Last year, profits totalled £18·3 million, £4 million more than in 1954. The company expect to finance a large part of the new scheme from their own resources. They are setting a very fine example to the rest of the industry.

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Mr. d'Erlanger and His Executives

At a Press conference last week, the chairman of B.O.A.C., Mr. d'Erlanger, outlined the function and responsibilities to be undertaken by himself, the deputy chairman (Sir George Cribbett), and the managing director (Mr. Basil Smallpiece). His statement did something to clear the air but hardly enough to restore the sorry position that followed the damaging statements of the Minister of Transport and Civil Aviation since Sir Miles Thomas resigned the chairmanship. But a good many retractions have been made.

(1) The part-time nature of the chairman's appointment, so widely criticised, was put in another light: "I regard myself not as a chairman on part-time duties but rather as a chairman of the board, free of executive responsibilities . . . I will of course devote as much time as may be necessary to the Corporation's affairs." Lord Rennell, who had resigned because he felt it was not a workable organisation to have a part-time chairman and a full-time deputy chairman, has rejoined the board now that it has been made clear that the chief executive's functions are to be entirely divorced from those of the chairman and the deputy chairman.

(2) The buy-British only undertaking given by Mr. Watkinson was put in a new perspective: the chairman has set up a committee to review the Corporation's future aircraft requirements, over which he will preside and on which will sit a pilot nominated by B.O.A.C. pilots. Mr. d'Erlanger stated that his clear objective was to see B.O.A.C. "become the most formidable and outstanding (airline) in the world" and that this would mean "making the best use of our staff and securing the right equipment for our purposes." Mr. Watkinson separately confirmed that it was the chairman's duty to do precisely that, but that "it is my duty as Minister to examine in the national interest whatever proposals for aircraft procurement the Board may put to me."

(3) The chairman's annual expense allowance of £2,000 a year has been reduced to £1,000 a year, "exactly the same amount and subject to the same conditions as his predecessor."

(4) Mr. d'Erlanger is in favour of the independent airlines going ahead as far as they can, so long as they do not encroach on or damage the prospects of B.O.A.C. In this he could not be more at one with his predecessor, Sir Miles Thomas.

Finally, there has been a flat denial by Mr. d'Erlanger that there is any intention to bring about a merger of B.O.A.C. and B.E.A. or to de-nationalise them: "certainly this is not part of my appointment nor that of the deputy chairman, and I have the authority of the Minister to say there is no such intention in his mind." But more than words will be required to make good the damage which has already been done to the management-labour relations of the Corporation. The union's reactions are discussed in a Human Element note in this issue.

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Tied Garage Controversy

Public interest has been aroused once again in the tied garage question by the public battle of words which has been fought in the last week or two between the Motor Accessories Manufacturers' Association and Shell-Mex and B.P. The Association complain about the restrictive practices of the Shell-Mex and B.P. group by developing, like certain other oil companies, a system of tied garages. Shell-Mex and B.P. have extolled the basis of mutual advantage and co-operation which their system brings, to themselves as the distributing side of a large oil group, and to the retail garage trade.

Behind the smoke of battle there looms the basic fact that both parties are inspired by fear. To quote from a pamphlet on the controversy put out by Shell-Mex and B.P., "The large investment of some £200 million in oil refineries in this country has naturally led the major oil companies to make greater competitive efforts to ensure their position in the retail market." The oil groups, in other words, are determined to secure their retail outlets to the motorist in order to defend their large investments in oil refining capacity. So far as M.A.M.A. are concerned, their latest memorandum on the subject says, "It is the agreements of Shell-Mex and B.P. which give the Association the greatest cause for anxiety. Those of other companies may be attacked on general grounds as being restrictive in the petrol field but that is not the primary concern of M.A.M.A." The latter are clearly much more concerned about the extension of the restrictive clauses to cover more than petrol than they are about the principle of the tied garage.

It is time to say something on behalf of the motorist. He has no interest in limiting the range of supplies obtainable at a garage, unless this service is better or the products are cheaper under a tied system. He suffers some inconvenience when he cannot choose his brand of petrol, lubricant or accessory. He may not like the idea of buying a certain brand of petrol because it is convenient to have his car overhauled regularly at the nearest garage. If anyone can prove to the motorist that he is better served by any form of restriction he will be pleased to take note of the facts. Meanwhile both the oil companies and the accessory manufacturers might well join forces in proving that a little more or a little less restriction will benefit the British motoring public.

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High Buildings in London

London has few high buildings. In Britain such buildings are mainly limited, apart from cathedrals, to industrial structures, but since the turn of the century other countries have been putting up multi-storied buildings which have become marks of civic achievement and pride. That this country has not erected such buildings may be attributed to the traditional solution to the problems of overcrowding, that of laying out "garden cities," first proposed 150 years ago at the time of the commencement of the Industrial Revolution.

In 1947, the Town and Country Planning Act recognised that Britain was too crowded, land too precious to squander on ever-spreading towns and that space should be developed to the greatest possible benefit. Such is the background to the several proposals that have been published recently for development projects in London. When to this is added the intention of the London County Council to continue the improvement of the South Bank of the Thames —begun with the building of the County Hall and followed more recently by the Festival Hall—

Model exhibited at this year's Royal Academy of Royal Dutch/Shell's proposed new offices on the South Bank of the Thames.

the conditions are ripe for high building to continue. It has been known for some time that the allocation made for offices on the South Bank had been taken up by the Royal Dutch/Shell Group, and plans now published in the form of a model at this year's Royal Academy, and shown opposite, show how Shell propose to accommodate all their London staff of 5,500 who are at present scattered among many different locations.

The new offices, two blocks on either side of the Charing Cross railway viaduct, have been designed by Sir Howard Robertson, A.R.A., P.P.R.I.B.A. The dominating feature will be the 26 storey tower, over 300 ft. high, and all the buildings will be faced in Portland stone with a character in keeping with contemporary British architecture. Taken in conjunction with the existing Festival Hall and civic centre of County Hall, and the plan to put a hotel nearby, the new offices, to be begun in 1957, will be a further step towards creating a new character for the South Bank.

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Capital for the Commonwealth

So much has been talked in recent years about the Colombo Plan, the International Bank and American aid (and, more recently, Soviet aid) that the development of relatively backward countries would seem to depend primarily on the charity of their more developed friends. While external finance is undoubtedly important, the part it plays is only a very small proportion of the whole as far as the British Commonwealth is concerned. "It provides, so to speak, the last links in the chain of resources that otherwise would not be enough to match achievement with planning," comments the report on "Economic Development in the Commonwealth," issued by the Central Office of Information last week.

The report covers production and development in the Commonwealth and shows that in fact about 82 per cent. of development costs in the public sectors of countries which have recently acquired Dominion or near-Dominion status is found from internal sources. Even for the Colonies the proportion is as much as 70 per cent. in many cases. In the private sector, the United Kingdom continues to remain the traditional source of supply of external capital. Broadly, this is facilitated in five ways. First, under the Colonial Development Welfare Act whereby the United Kingdom Government have agreed to make available £20 million for development in the period 1955 to1960; second, through the Colonial Development Corporation, which by the end of 1954 had capital commitments of over £47 million; third, by means of sterling loans to the International Bank for Reconstruction and Development, which since 1953 have totalled £24 million (£5 million of which went to the Indian steel project); fourth, through sterling grants under the Colombo Plan, which in the first four years of its operations amounted to £50 million; and fifth, through loans raised on the London Money Market, both public and private. Between 1948 and 1954, £128·4 million was raised by Commonwealth governments through this medium, and in 1954 private capital borrowings from the London Market totalled £48 million.

Meanwhile, aid from outside the Commonwealth countries continues to come mainly from the United States. Under Mutual Security Aid, India and Pakistan received 510 million dollars between July, 1951, and June, 1955. The Export-Import Bank has authorised loans totalling almost £100 million to Commonwealth countries since 1952, while the International Bank has supplied an additional £250 million since 1951. In addition to aid from Britain and the U.S.A., Colombo Plan countries received grants totalling £60 million from Canada, Australia and New Zealand between 1951 and 1954.

While the value of external aid may be small in relation to total capital commitments, quite obviously its importance in global terms is great. The development of the Commonwealth is a necessary and valuable concomitant to Britan's economic prosperity, both in the matter of direct exports as well as of gold and dollar reserves. The Colonies are valuable markets for the former, and valuable earners of the latter.

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Turbines, Telescopes and Atoms

Whatever the arguments for combining the offices of chairman and managing director, there are not many companies, like C. A. Parsons and Company, Limited, who can boast that their chief executive is a Fellow of the Royal Society. It is remarkable, too, how closely the background of the senior personnel and the general complexion of a company's affairs seem to reflect one another. C. A. Parsons have always differed somewhat from the other makers of large turbo-generators and heavy electrical machinery and plant. This difference is not only in their having an important marine side to their business, but also in their optical division, operated as a separate unit under the name of Sir Howard Grubb, Parsons and Company, and responsible for the manufacture of astronomical telescopes and a range of instruments.

They have always been in the van of engineering research. The Nuclear Power Plant Company (which they have formed in conjunction, among others, with their associated company A. Reyrolle and Company, and their neighbours on the north east coast, Head, Wrightson and Company, Whessoe Limited, and Clarke, Chapman and Company) is not backed by such giants as some of its rivals in the application of atomic energy, but it is likely to be a lively competitor. Atomic energy is a field where ideas are the main motive force and where there is unlikely to be much standardisation of technique for another decade at any rate. Head Wrightson's wide experience in the field of petroleum refinery plant should make them valuable partners, and the same applies to Whessoe, partly for the same reason and partly because of their link with Shell.

The pace of C. A. Parsons' technical development is illustrated by their transfer to general reserve last year of £1·5 millions out of the net profit after tax of about £2 million—i.e., about three-quarters of the profit. Why is it that "capital" continues to have such a bad name? Sins of the fathers, perhaps, who accumulated the capital but so often failed to risk it on new ventures and new technical developments. Capitalists and scientists are not always good partners. Perhaps, under the shadow of Sir Charles Parsons, they get on better than usual.

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Landscape Treatment of Trunk Roads

The Ministry of Transport report that another committee to consider trunk roads has had its first meeting. The committee will advise the Minister on the choice of routes and on landscape treatment of new motorways. Admirable as the intention of the committee is (no-one would want to have endless stretches of dual carriage-way with hardly a change in gradient as characterises roads in some parts of the world), it is a little difficult to see how, in England and Wales, there can ever be a choice of route which does not immediately raise either engineering problems or unnecessary disturbance of agricultural land. Since the committee are specifically directed to bear in mind the engineering difficulties likely to arise from their recommendations, it might have been better if one of them had been an engineer, preferably with first-hand knowledge of the effect that adjacent vegetation can have on the road slab.

The technical problems of road construction are briefly discussed elsewhere in this issue, in a review of the Road Research Laboratory's book *Concrete Roads: Design and Construction*. There is no doubt that all the necessary technical knowledge is available. What is badly required is the experience to test out the conclusions and results of experiment and prodigious thinking during the past ten years. The principal obstacles preventing motorways being built here are neither technical nor financial, but are the consequences of social conservatism which battles for the rights of vested interests, whether they be the railways, the farmers, or the old dear who for 80 years has occupied a cottage on the line of the new road.

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Diesels in Demand

Recently published figures have shown that the outlook for Diesel engines continues good. In 1955, British exports of Diesel engines came to £29·6 million compared with £26·5 million in 1954. Competition in foreign markets has been fierce for some time and the Germans in particular have made great strides with air-cooled engines. The onset of full employment in Western Germany, however, may force up German prices, enabling British manufacturers to consolidate their recent gains.

In the home market, despite the credit squeeze, the outlook for Diesels remains healthy. The average monthly delivery of internal-combustion engines in 1955 was 36,100, compared with 29,400 in 1954, and on the automotive side the average monthly delivery of commercial vehicles last year was 19,534 compared with 15,987 in 1954. The production of most "end uses" of Diesel engines continues buoyant. Thus, for example, output of contracting plant of all kinds rose to new levels in 1955 and there is as yet no sign of a slackening of demand. To help maintain prospects in all home markets there still looms the Diesel engine's best friend—the tax collector. There was an eloquent silence in the Budget about remission of duty on petrol.

Against this background, the results of both F. Perkins, Limited, and the Brush Group have been published in the last two weeks. The phenomenal rate of expansion of Perkins continued through 1955. Turnover was raised by 18 per cent. last year. It is significant, however, that this continuing high rate of expansion of sales was not accompanied by a corresponding increase in net profits. These actually declined on the year. The reduction in profit is said in the chairman's statement to have been mainly due to the heavy development expenses of the R.6 engine, but there have also been increases in costs. Engine prices have not increased since February, 1952. In the case of Brush, net profits have also been reduced in the financial year ending December 31, 1955. Turnover increased while gross trading profits were almost unchanged. So far as the trading account is concerned, therefore, Brush and Perkins have had a similar experience. In the Brush Group, Petters, Limited, are developing a range of air-cooled engines of lighter weight and higher speed. Tooling has been completed and line production has now started on the P.D. air-cooled series of J. & H. McLaren, Limited. The range of horizontal engines put out by the National Gas and Oil Engine Company Limited has been rationalised, while Mirrlees, Bickerton and Day, Limited, report excellent business in the marine and industrial fields.

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Cars and their Prices

Recent news from the motor-car industry suggests that the worst of the seasonal lull has gone but the news is, on balance, less than good. In April, according to Hire Purchase Information, there was a recovery of 16 per cent. in credit business in the motor vehicle industry compared with March, but business was 16 per cent. lower than in April, 1955, and this drop follows a decline of 20 per cent. recorded for March, 1956, compared with March, 1955. Although the main brunt of the drop seems to have been borne by agricultural tractors, private car deals were down, especially those in second-hand cars. Motor-cycle credit sales were also badly hit. Only commercial vehicles showed any resilience.

Probably the main lesson of recent events in

the motor vehicle industry, when full allowance has been made for the Government's deflationary policy, is that the seasonal trend is back and that it is going to re-assert itself in a more severe form than the optimists had hoped. Severe seasonal fluctuations in sales will, if they persist, face the car industry with problems which it has not had to grapple with for over 15 years. Companies are faced with the need to conserve their core of skilled labour by making price reductions (a symptom which has appeared both in this country and in Germany last week). Originally the Motor Show was held in order to persuade the public to buy cars in the off-season. More hard thinking along these lines may now be necessary for the industry. If the car manufacturers are faced with the problem of fluctuating sales while full employment in the economy at large is maintained, they will be under a double pressure to find some device of salesmanship or credit selling to spread their sales more evenly over the year. Large numbers of new cars cannot be parked on open ground indefinitely, and men cannot be taken on and dismissed at will. A recognised reduction in prices during the off-season may be the solution, but the idea will require to be publicised convincingly.

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Machinery for Farmers

Mr. A. W. Tuke, chairman of Barclays Bank, Limited, referred last week in an address to the Farmers' Club in London, to the growing needs of agriculture for long-term capital. He reminded them of the facilities which are available through the Agricultural Mortgage Corporation. He endorsed the opinion, which is fairly widely held, that the farming community needs about £400 million of additional capital in order to increase its efficiency and make its optimum contribution to reducing the burden of imported food and feeding stuffs.

Figures of this size are a reminder of the major role of the agricultural machinery industry to-day. Recent figures of the annual gross capital formation by the agricultural industry are not available but to judge from statistics available for 1954 it must be running in the region of £100 million a year at present. In 1955, the total output of agricultural machinery was probably about £160 million, of which £60 million would be for export. This represents a production per annum of something like 150,000 agricultural tractors, 35,000 market garden tractors, 35,000 ploughs, 20,000 mowers, 10,000 pick-up balers, 6,000 combine harvesters and 10,000 milking machines, as well as a wide range of other types of equipment. There is a good deal of publicity given at times to the output of agricultural tractors, but the level of output of agricultural machinery as a whole has remained remarkably steady in the last four or five years. The process of mechanisation now represents a steady and sustained effort after the tremendous rate of expansion in the first few years after the war.

In the face of figures of this dimension it is clearly wrong to think of agriculture as a Cinderella industry manned by unskilled labour. It is fast becoming an industry which plays a critical part in the level of total engineering activity. Skill and flexibility are required not only in management but among the operatives as well. The day may not be far distant when the idea of a machine operator takes the place of the traditional concept of a farm hand.

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Lenses, Machines and Instruments

The trade mark Taylor-Hobson suggests to many engineers mechanical engraving machines. To others it means measuring instruments. Photographers know it on optical lenses. The connections between the three branches of the Taylor-Hobson business may not be obvious at first sight, but the machines and the instruments developed logically out of the needs of the original branch of the business, and they now command wide markets in their own right. How these developments took place was illustrated by an exhibition held recently at the works of Taylor, Taylor and Hobson, Limited, Stoughton-street Leicester, when the company celebrated their 70th anniversary.

T. S. Taylor, who had been apprenticed to a firm of microscope makers, was the actual founder of the present business. In 1886, he rented the top floor of a factory in Leicester, and after a few months he was joined by his brother William Taylor. W. S. Hobson joined the firm as a partner in 1888. The Taylor brothers started to make conventional optical lenses, and almost at once they found that if they wanted equipment they would have to design and make it themselves. One of the first developments recorded was in the engraving of lens mounts, on which it was necessary for the makers' name to appear, together with the description of the lens and the iris scales. To do this by hand would be slow and costly, and in 1887, the Taylor brothers produced the mechanical engraver which is the basis, geometrically, of the machine of to-day. In the optical lens field the firm took a step forward in 1893, when they obtained the exclusive manufacturing rights for the " Cooke " lens.

The very precise limits to which optical lenses and their mounts have to be made, and the absence of proper standards in the early days of the Taylor partnership, led the brothers to study the question closely. The standardisation and measuring of threads for lens mounts was a question which received early attention, and this was the background to the firm's business in measuring instruments, with which the engineer is quite familiar.

The outstanding position reached by the company in the manufacture of optical lenses brought them into close connection with the cinema-equipment industry at quite an early date, and their products were well known in America. In 1931, a controlling interest in the business was obtained by the Bell and Howell Company of Chicago, but in 1945 control was returned to this country when Mr. J. Arthur Rank arranged for Taylor, Taylor and Hobson to become a subsidiary of Rank Precision Industries, Limited. To-day the connection with the film industry both at home and overseas is on a firm basis and a large proportion of American films are photographed with Taylor-Hobson lenses. Of the total output of the company, of all products, 40 per cent. is exported, the most important customers being the U.S.A. and Germany.

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"Weapon of Ultimate Destruction"

An official statement has been released from Washington which concerns the progress made by the United States in the design of ultra-long-range missiles. This statement is one of the most serious ever to receive publicity.

A weapon designated the " Intercontinental Missile," complete with hydrogen head, which can reach any target in the world in a matter of minutes, is ready to go into production. All design problems have been solved, and it only remains to go ahead and build it. The effect, as can well be imagined, on a city area, has prompted the Americans to refer to this missile as " The Weapon of Ultimate Destruction." While no time is given for the manufacture, if and when it begins, past experience tends to show that America only releases news of such vital importance after she is well ahead with the practical, as well as with the theoretical, conditions upon which such projects are based. It is further stated that a hit on any selected city can be guaranteed—a claim which certainly involves an extraordinary degree of accuracy in control if the weapon is to be employed at extreme range. Once again, the United States usually live up to their claims in the military field, so that henceforth defence strategy may have to be sensibly modified in the light of this latest engineering and scientific achievement.

It is well known that other countries are experimenting on similar lines, and we are only too painfully familiar in England with short-range guided missiles; but all that sinks into relative insignificance beside the fact of a practical weapon that can be launched from a hidden site to span the globe. One immediate conclusion is that no country, however vast, can completely protect its armament industry by dispersal.

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Reassembling the Ruhr

Barely ten years ago, the Ruhr, the traditional centre of the German coal, steel and engineering industries, was a war-devastated area faced with the prospect of years of control by the Allied military commanders, who were determined to neutralise the German armaments industry. This regime lasted until 1948, when three major events occurred. These were the reform of the currency, the beginning of Marshall Aid, and the admission of Germany to O.E.E.C. The resulting changes made it possible for Germany to re-enter world markets. The counterpart funds to which the Marshall Plan gave rise provided a source of capital for the requipment of industry which had found self-financing impossible under price control. The currency reform measures restored incentives and brought saving and investment back into the realms of the possible. In consequence, in 1948, the Ruhr was able and ready to make a fresh start and, thereafter, German industrial recovery has been headline news. By the middle of 1954 industrial output had risen by 230 per cent. and exports reached 56 per cent. over the 1936 level. Behind the scenes, the pattern of the Ruhr industries had begun to return to what it had been before 1945.

As an attractive alternative to continued Allied supervision of the Ruhr, Germany accepted the invitation to join the European Coal and Steel Community, formed as the result of the Schuman proposals of May, 1950. The High Authority, however, have no jurisdiction over the engineering or any other industry with which the steel companies establish links, and mergers have taken place. Thus, in 1945, the Klockner-Werke company of Duisburg was split up by the Allies into eight parts and, at the same time, its coal, chemical and engineering interests were segregated. The report of the company published in December, 1955, shows that, in one form or another, the constituents have all come together again like the parts of a jig-saw puzzle. The same process has been going on with other combines such as Mannesmann and Gutehoffnungshütte.

The Ruhr industries have now reached a most interesting position. Like the rest of German industry they are facing the problems arising from full employment and the shortage of coal. Rationalisation and modernisation are still only in their early stages and a great many new developments are likely to be seen in the next year or two. The big questions are whether capital will be forthcoming in sufficient quantities to make these changes possible and whether the coal output can be raised to meet the home demand. The emphasis in both cases is on increasing the size of the unit of production and there is little doubt that the mergers that have taken place so far are only a beginning.

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Turbine Engineers

Five members of the staff of Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, have taken up new appointments as from March 1. They are Mr. L. S. Robson, as assistant chief mechanical engineer; Dr. D. M. Smith, chief engineer, Mechanical Engineering Development; Mr. J. S. Hall, chief engineer, Steam Turbine Engineering Department; Dr. W. H. Darlington, chief engineer, Gas Turbine and Gear Engineering Department; and Mr. J. V. Bigg, chief engineer, Condenser and Heat Exchange Engineering Department.

THE FORMABILITY OF ALUMINIUM ALLOYS

By D. A. Barlow, M.SC.*

In the following article the author has approached the problem of the forming capacity of aluminium alloys from a theoretical aspect in an attempt to establish a sound basis for the great variety of forming operations now employed in industry.

In the manufacture of any article, it is generally fairly easy to decide what forming operations, such as bending and deep drawing, are necessary, and ample information is available on the appropriate technique and equipment. In the case of metals such as brass and mild steel, there is also a wealth of experience to draw upon. Little difficulty is met with in deciding how much deformation the material can withstand in each operation, so that the number of operations and intermediate anneals (if any) can be determined and the tools made without fear that the demands on the material are excessive. Rules of thumb are often available giving reasonably good results with the more commonly used materials. With aluminium alloys, however, while there are a few such rules which can be applied to commercially-pure aluminium in the soft temper, there are no rules applicable to other tempers or to other alloys, and previous experience is often scanty.

The aluminium alloys have widely different ductilities. The demands made on the material also vary, so that an alloy which is the best for one operation may not be the best in another operation involving a different stress system. For example, commercially-pure aluminium in the soft condition is one of the most ductile aluminium alloys for stretch forming, but in deep drawing it is surpassed by a number of other alloys, some of which are rather poor in stretch forming. If tool and product designers are to use the most suitable alloy and the fewest number of operations, they must know the forming limits or ductility of each alloy and temper in each type of operation. These limits can be determined experimentally, but this involves an enormous amount of work even when the number of alloys and operating variables, such as tool dimensions, etc., is small; and without the theoretical background or knowledge of the mechanism of the forming processes it is impossible to apply the results obtained to other alloys and tools. The need for a theoretical study of forming operations is thus apparent, both to enable intelligent use to be made of existing data and to assist in the solution of practical difficulties. A knowledge of the behaviour of the metal in the common forming operations would also be a useful guide in assessing operations on which no previous experience is available.

The present article is based on a study of the literature and on experimental investigations carried out at Aluminium Laboratories Limited. Forming operations are classified according to type, and the limits to which the various alloys may be formed are determined. Discussion is confined to operations carried out by the manufacturer of the end product; fabricating processes such as rolling, extrusion and tube drawing are excluded. Spring-back and internal stresses after forming are not discussed, and forming loads are only considered in so far as they affect the forming limits.

In considering whether a given part can be formed, there may be more than one type of operation involved, but it is generally fairly easy to decide which is the controlling one. Thus a deep cup-shaped part may involve deep drawing, curling of the rim and raising a design on the base, the deep drawing being the most severe operation. On the other hand, in a shallow cup with small corner radii the bending over these radii may be the limiting factor.

CLASSIFICATION OF TYPES OF FORMING OPERATION

Forming operations may be classified as follows:

(1) Stretching or tensile.
(2) Shrinking or compressive.
(3) Bending.
(4) Deep drawing.
(5) Ironing.

Operations such as coining and impact extrusion are omitted because the forming limits are set by the tools rather than by the material.

SECTION I: STRETCHING OR TENSILE OPERATIONS

BEHAVIOUR IN TENSILE TESTS

Before discussing the various tensile forming operations, it is useful to examine the behaviour of a tensile test piece under load (Fig. 1). The elongation of a tensile test piece consists of two parts: a general or uniform elongation, and the local elongation at the neck at fracture. The general elongation is dependent primarily on the rate of work hardening and the uniformity of the material, and in a parallel uniform specimen is the elongation at maximum load. Up to the maximum load the material strengthens as a result of cold work at a greater rate than it weakens due to thinning, so that the load increases and elongation takes place uniformly. At the maximum load the rate of strengthening due to work hardening is equal to the rate of weakening due to thinning; beyond it the material is still work hardening but is thinning more rapidly, and the load begins to fall. If the material were perfectly uniform and the test piece of constant cross-section, uniform extension would continue after the maximum load had been reached, until the whole test piece disintegrated at fracture. In practice, no such uniformity is obtained, so that, beyond the maximum load, deformation ceases except at the weakest point; and since the load is dropping it continues at that point until fracture. Because necking occurs at the weakest point, the remainder of the specimen does not reach its maximum load or ultimate tensile stress, and therefore does not quite develop its full general elongation.

The local elongation is the elongation at fracture on zero gauge length and is a measure of the total deformation the material can withstand before fracture. It is equal to the difference between the original area A_0 and the final area A_1, divided by the final area, or $\frac{A_0 - A_1}{A_1}$, if there is no volume change. The maximum volume change is about 0·2 per cent. and can be ignored. It should be noted that the stress at the neck of a test piece is not pure uniaxial tension, as it was prior to necking, but is triaxial tension (unbalanced). It is well known that ductility under triaxial tension is less than under uniaxial tension. If uniaxial tension only is present and necking can be prevented, as in some types of forming operation, deformation in excess of the local elongation at the neck of a tensile test piece can be obtained.

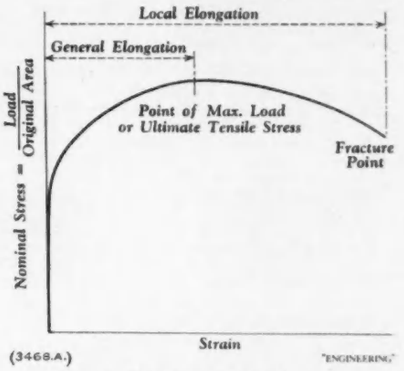


Fig. 1 Tensile stress-strain curve.

STRETCH FORMING

Stretch forming (Fig. 2) is often used for making curves of large radius in sheet and sections, where the difficulty in forming by normal bending methods is not lack of ductility but the large and variable spring-back—a problem which does not arise in stretch forming. The process is also used for parts with double curvature which cannot easily be made in any other way. The sheet or section to be formed is gripped firmly at opposite ends and wrapped round a punch which is then pressed into the material, thus stretching it to the desired profile. The grips may be pivoted so that tension is always transmitted in line with the unsupported ends of the material, or they may be fixed when used with sheet. In the latter case, the edges of the jaws must be given a radius of at least 15 to 25 times sheet thickness, to avoid failure at the edge of the jaws, unless the stretch required is a light one. This radius should

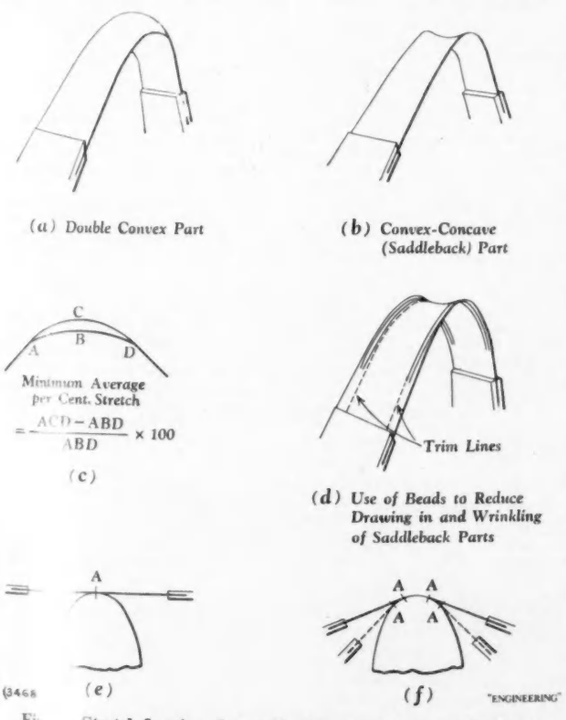


Fig. 2 Stretch forming, for making large radius curves in sheet.

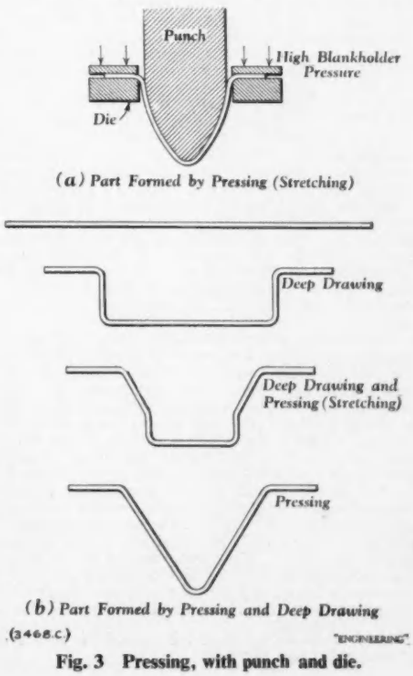


Fig. 3 Pressing, with punch and die.

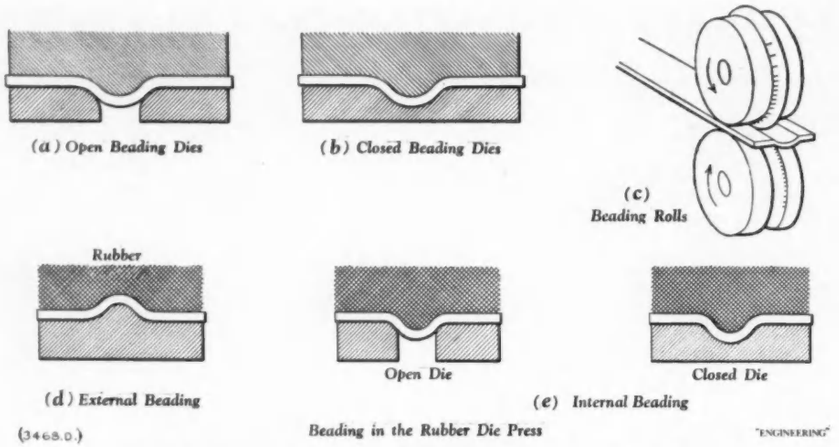


Fig. 4 Beading by rolling and pressing; rounded profiles are to be preferred.

be smooth but unlubricated since the friction over the radius reduces the stress concentration at the edge of the grips.

In forming single curvature parts the material is generally draped or wrapped round the punch, usually with an initial tension up to the proof stress, and the punch is then given a small traverse to "set" the curve, i.e., just sufficient stretch to eliminate appreciable spring-back. Often less than 4 per cent. stretch is needed, so that material of almost any alloy or temper can be formed. If the material is not draped round the punch, the stretch required to form the part is considerably greater.

Double curvature parts (Figs. 2*a* and 2*b*) may be of double convex or of convex-concave curvature (saddleback). The average stretch required for such parts is much greater than for single curvature parts and is equal to the difference in length between the longest and shortest paths (Fig. 2*c*); the maximum stretch required exceeds this by perhaps 50 per cent., depending on the dimensions, because the stretch is not uniform over the contour. An additional stretch of 1 to 2 per cent. is required to eliminate spring-back. Longitudinal wrinkles may form on saddleback parts but they can usually be avoided by adding beads to the punch to prevent the sheet drawing in (Fig. 2*d*).

Forming Limits.—The maximum stretch which can be developed in single curvature parts is the general elongation in tension, although this amount of stretch is not usually needed. To obtain maximum stretch, the edges of the material must be smooth—the stress concentrations at a sheared edge may reduce the available stretch by 50 per cent., the strong alloys being more sensitive to edge conditions. Fracture usually occurs in the unsupported material between the punch and the grips. If the sheet is draped over the punch before the latter is traversed, the part "locks" on to the punch if friction is high. The locking action limits the stretch over the punch, and good lubrication is required with parts of single curvature to obtain a stretch approaching the general elongation. The lubricant should be of the "boundary" type, such as soap, waxes, etc., as speeds are very low. Where a fairly large stretch is needed, as on double curvature parts, it may be useful if the punch can be arranged to move during the draping instead of afterwards. With parts of sharp, and especially double curvature, some friction at the crown of the punch is required to prevent local deformation at that point and penetration of the sheet by the relatively sharp punch.

The limiting stretch normally obtainable under suitable conditions on double curvature parts is the general elongation under biaxial tension. Swift[1*] has shown that this general elongation can be determined from the true-stress/true-strain diagram in simple tension if the ratio of the two tensions is known. Using this method it can be shown that the general elongation under balanced biaxial tension (i.e., the two tensions being equal) is equal to the simple tensile general elongation; under intermediate conditions (unbalanced biaxial tension) the general elongation may be up to 20 per cent. greater or 10 per cent. less than the simple tensile general elongation. Thus, for practical purposes it is not necessary to know the ratio of the two tensions, because the departure from the simple tensile general elongation is not large and will be covered by the usual "safety factor" necessary to allow for variations in material.

Dorn and Lotze[2] have shown that it is sometimes possible to obtain stretches exceeding the general elongation, and approaching the local elongation, particularly when forming at elevated temperatures. In the latter case "necking down" often sets in, but is spread over a large area, so that an acceptable part is produced. Sachs and Espey[3] have concluded that the stretch obtainable, particularly at elevated temperature, is a complex function of the geometry of the part, the movement of the ram and grips, and the friction between the part and the punch, and it seems that the conditions used by Dorn and Lotze happened to be particularly favourable. A possible mechanism whereby a stretch approaching the local elongation can be developed is given below.

Consider the sheet at the moment of contacting the punch (Fig. 2*e*). Deformation will be concentrated at the line of contact. If punch friction is high, the sheet will "lock" on to the punch and deformation will then continue on either side of the area of contact (A-A, Fig. 2*f*) as the sheet is wrapped round the punch. If the correct tension at each instant is applied to the sheet and if it is wrapped round the punch at a suitable speed, the stretch at either side of the area of contact with the punch can exceed the general elongation and be well in the "necking" range, provided that the "neck" contacts the punch before failure can take place. This necking would occur to each element of the sheet in turn as the forming cycle proceeds so that a uniform stretch exceeding the general elongation would be obtained. With single curvature parts, the necks at points A-A would form straight across the sheet, so that the conditions for exceeding the general elongation would be very critical and failure would occur very easily. On the other hand, with double convex parts the necking area would be some form of closed curve, consequently the sheet would be less likely to fail. With parts of severe double curvature, conditions would be very critical and very high punch friction would be required. The above mechanism would account for the fact that Dorn obtained the greatest stretches on parts of moderate double curvature and the least stretches on parts of single and severe double curvature.

The most ductile condition for stretch forming is generally the annealed condition, but it should be noted that some heat-treated alloys have as much general elongation in the naturally-aged as in the annealed state. The effect of directionality can be ignored, as this is generally small.

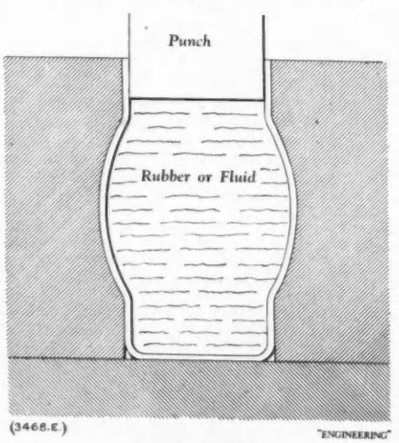


Fig. 5 Bulging.

PRESSING

The term pressing (Fig. 3) is often applied loosely to include any article formed in a press. "Pressing" is used here to denote the operation whereby sheet is formed between a punch and die by stretching. Superficially, pressing resembles deep drawing, many operations being a combination of the two processes: but whereas in deep drawing the sheet is allowed to flow freely into the die, in pressing, movement of the blank as a whole is prevented by a spring- or pneumatically-loaded blank holder. The blank holder pressure must therefore be very high; alternatively, the same effect can be obtained if a large blank is used so that the flange prevents drawing in.

If the punch is flat-bottomed, or substantially so, shallow pressings only can be produced, since the walls have to take all the stretch. Deep flat-bottomed parts must be drawn. Where the punch is conical, parabolic, etc., in shape as compared to flat-bottomed, the sheet must not be allowed to draw in freely or puckers will form over the punch (not to be confused with wrinkling over the die). With soft materials and a hemispherical punch it is usually possible to allow the sheet to draw in, i.e., to deep draw the material, as the deep-drawing load is sufficient to stretch the sheet over the punch without puckering; but since the stretch is considerable, only alloys with considerable general elongation are satisfactory.

Forming Limits.—As pressing is simply stretch forming, the forming limit is the tensile general elongation. Calculation of the amount of stretch required for a given part may be very difficult, especially where some drawing in of the sheet takes place. The stretch will vary from point to point and although the average stretch can be calculated if there is no drawing in of the sheet, the maximum stretch cannot. Many parts cannot be formed in one operation by stretch alone, because the amount of stretch required would be excessive, and they are therefore formed in stages by drawing followed by stetching (Fig. 3b). In these cases the stretching, and therefore the general elongation, is the limiting factor.

BEADING

Beading (Fig. 4) may be done in a press with metal punch and die (Figs. 4*a* and 4*b*), between shaped rolls (Fig. 4*c*), or in the rubber die press (Figs. 4*d* and 4*e*). Where discontinuous beads are formed in sheet, conditions are similar to those in pressing. If the area of sheet surrounding the bead is large, no drawing in of the metal can take place, and the bead is formed by two-way stretching. The average stretch required can be determined from the profile of the bead. Sharp corners should be avoided, and it should be remembered that in the case of a flat-bottomed bead the flat surface stretches very little, so that the sides have to take most of the stretch: a rounded profile is therefore to be preferred. Where the surrounding area of sheet is small and clamping forces are not high, some drawing in can take place and slightly deeper beads can be obtained. Where a continuous bead is formed near the edge of a sheet, the material is free to draw in unless the tools are very rough. In this case the bead is formed by bending rather than stretching, the only limit to the depth of the bead being the bend radii.

Where continuous circumferential beads are formed on cylindrical parts, they may be made by rolling, by expansion of a segmented punch, or by fluid pressure. Generally, the cylinder is free to contract longitudinally, so that the metal is subjected to circumferential tension only. If the material is not free in the longitudinal direction, two-dimensional stretching takes place. Where fluid or rubber pressure is used, and profiles other than that of the usual bead are formed, the operation is called expanding or bulging (Fig. 5).

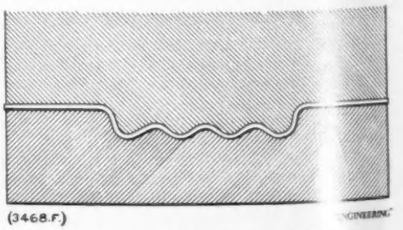


Fig. 6 Embossing or raising

* References are given at the end of this section of the article, page 332.

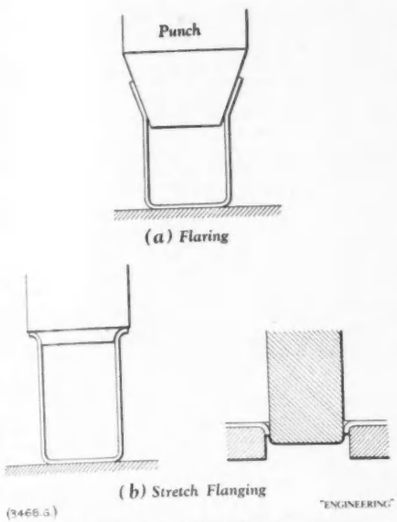


Fig. 7 Flaring and stretch flanging.

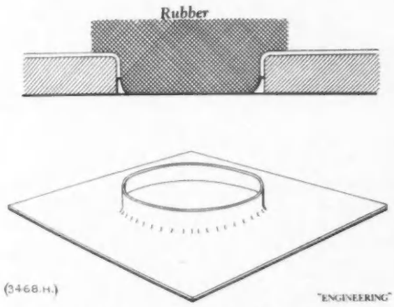


Fig. 8 Stretch flanging in rubber die press.

Dorn, Cunningham and Thomsen[4] have carried out beading tests in a rubber die press on a variety of aluminium alloys and have found that if the bead is of circular section, as is usually the case, the stretch over the bead is almost uniform. Under these conditions it would be expected that the general elongation would determine the maximum depth of bead obtainable, but in fact the limiting stretch was only about half the general elongation of the material. Failure occurred at the junction of die radius with the bead radius before the general elongation was reached over the bead surface, perhaps because of the complicating factors of the bending and the radial pressure of the rubber.

EMBOSSING

The process of embossing or raising is used for producing designs, lettering, etc., on sheet (Fig. 6) and may be combined with other press operations. It is essentially two-dimensional stretching, as the surrounding sheet will prevent drawing in so that the operation resembles beading and will have a similar forming limit. When the design must be sharp, however, the bend radii will be small, and this may be a limiting factor.

FLARING AND STRETCH FLANGING WITH METAL TOOLS

Flaring is the expanding of the mouth of a tube or other cylindrical part by means of a tapered plug or punch (Fig. 7*a*) or by means of a rotary swaging tool. This gives the equivalent of circumferential uniaxial stretch and the general elongation determines the limiting stretch. However, the general elongation in the circumferential direction on tubes may be somewhat less than that in the longitudinal direction, which is the direction in which the material is normally tested. For the maximum stretch, the edge must be smooth and polished.

The flanging of stretch flanges on cylindrical parts and the flanging of holes in sheet, Fig. 7*b*, are similar to flaring since the radius is usually generous and does not limit formability. In the flanging or flaring of spun or deep-drawn parts it should be remembered that these have already received considerable cold work and may have very little general elongation. If a segment is being flanged, instead of the full circle, the free edges of the segment do not stretch, so that on small segments the amount of stretch is reduced and higher flanges can be obtained.

STRETCH FLANGING WITH THE RUBBER PRESS

When rubber is used instead of a metal tool for flanging, as in the flanging of lightening holes in sheet parts (Fig. 8), it is possible to get much greater deformation than with metal tools. If the flange radius is generous, the material fairly uniform and the edge of the hole smooth, the deformation possible on this edge exceeds the general elongation and frequently approaches the local elongation. It is known that the friction between the rubber and the metal is very high and that little if any relative motion occurs. In these circumstances all deformation of the sheet follows that of the rubber. The latter, being highly elastic, resists local stretching, and so equalises the deformation of the sheet, unlike metal tools, which allow local necking to take place. The stage at which local deformation followed by fracture begins depends on the friction between the rubber and the sheet. Dorn, Cunningham and Thomsen[5] found that the maximum stretch obtainable exceeded the general elongation and was about half the local elongation for annealed alloys, up to a maximum value of 65 per cent. stretch, and equal to the local elongation for heat treatable alloys, up to a maximum value of 35 per cent. stretch. As in flanging with metal tools, when a segment only is being formed, the free edges do not stretch, and if the segment is less than about 60 deg. the reduction in stretch allows higher flanges to be produced.

CURLING AND WIRING

" Curling " consists of the turning over of the edge of a sheet part to form a hollow rim (Fig. 9*a*); where a wire or rod is incorporated, the operation is termed " wiring " (Fig. 9*b*). The operations are performed by pressing in a die (Fig. 9*c*) or by spinning (for circular parts only). Where the part is straight, bending only is involved (this is dealt with later, under the appropriate section). Curved parts involve stretching and shrinking of the sheet in addition to bending. If the bend radius is small it may be the critical factor, but if it is generous the ductility in stretching and shrinking must be considered. In forming a rim on the outside of a curve (Fig. 9*d*) the sheet is first stretched to the maximum diameter of the rim and then shrunk back to approximately its initial diameter. The percentage deformation is therefore readily determined and the general elongation will give the limiting stretch if the edge is smooth. As with flanging and flaring, it should be remembered that spun or deep-drawn parts have already received considerable cold work and may have very little general elongation. The shrinking is not so critical, as the compressive ductility of aluminium alloys is always as great as, and generally much greater than, the tensile ductility (see Section II below) so that if the material will withstand the stretching of the rim it will have ample compressive ductility.

In curling operations, a possible form of compression failure is by buckling. If the rim is wired, the sheet is supported by the wire on one side and the tool on the other, so that buckling is prevented. With rims of the proportions normally used, however, buckling is seldom experienced whether the rim is wired or not. In forming a rim on the inside of a curve (Fig. 9*e*) the sheet is first compressed and later stretched. The conditions will therefore be slightly more severe than before because the sheet is further cold worked before stretching (which is the critical operation) is carried out. When curling or wiring by pressing, the edge of the sheet should always be given a slight " lead " (Fig. 9*c*): without this, " peaking " or kinking of the sheet will occur (Fig. 9*f*).

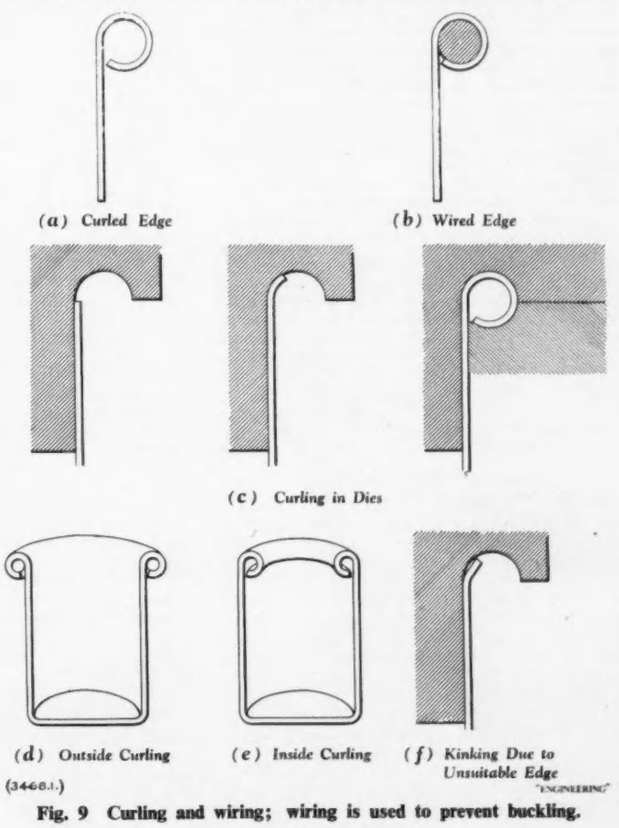
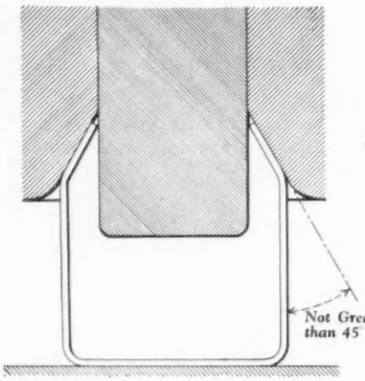


Fig. 9 Curling and wiring; wiring is used to prevent buckling.

SECTION II: SHRINKING OR COMPRESSIVE OPERATIONS

BEHAVIOUR OF MATERIAL IN THE COMPRESSION TEST

In compression, unlike tension, there is no local contraction—any deformation at one point results in thickening the material instead of weakening it, so that further deformation continues elsewhere, i.e., all deformation is general. If a fundamental relation exists between tensile and compressive ductility, the reduction of area in tension calculated on the final area $\left(\frac{A_0 - A_1}{A_1}, \text{ where } A_0 > A_1\right)$ should compare with the increase of area in compression calculated on the original area $\left(\frac{A_1 - A_0}{A_0}, \text{ where } A_1 > A_0\right)$. In measuring compression properties, deformation at the ends is restricted and the test piece assumes a barrel shape, owing to friction between the ends of the test piece and the platens. Since the specimen is not in pure compression, it might be expected that the ductility would be reduced. In spite of this the increase of area for most aluminium alloys is as great as and often much greater than the tensile reduction of area.[6] It is worth noting that when compressive failure occurs, it is usually by fracture in shear at about 45 deg. It is probable that in tension any local fissures, weak points or other form of inhomogeneity, whether on a macro or a micro scale, tend to open out and cause failure, with relatively low ductility. In compression, such fissures would close up and have much less effect on ductility. The tensile properties of a material may therefore give little indication of its compressive ductility; thus, many strong alloys are more ductile in compression than would be expected, and material in the fully heat-treated temper is often more ductile than in the solution-treated and naturally-aged temper. If the ends of the compression test piece are lubricated, " barrelling " is reduced and the ductility may be doubled, the increase depending on the alloy; some strong alloys, however, show reduced ductility on lubrication in spite of diminished barrelling. Lubrication does not affect the loads in a compression test to a great extent, although it may considerably reduce the loads in other operations where compression is involved, e.g., shrinking of cylindrical parts. In many compressive operations, the limiting factor



(3468.K) "ENGINEERING"

Fig. 10 Shrinking.

is not the compressive ductility but buckling of the part.

RIVETING, COLD FORGING OF BOLT HEADS ETC.

In these operations the rivet or bolt heads may be formed by squeeze or single- or double-blow machines, or by hand or pneumatic hammer when driving rivets in the field. The compressive ductility is the limiting factor in each case. The shape of the rivet or bolt head affects the ductility—most snaps or dies partly enclose the material giving triaxial compression, thus increasing the ductility (although to a variable extent) so that it may be safely assumed that a material will form a head if it will withstand the same amount of deformation in a free compression or flattening test.

SHRINKING OF CYLINDRICAL PARTS

The process of shrinking of cylindrical parts (Fig. 10) consists of tapering the mouths and closing over the ends of tubes and other cylindrical parts, and may be carried out by pressing in a die, by rotary swaging tools, or by spinning on a collapsible or offset stationary mandrel, or on "air," i.e., a wooden wedge held by the operator. As the operation is compressive, the wall thickness is increased and there is usually ample ductility. It should be noted that the edge of the material should be fairly smooth—a nick may lead to folding and cracking at that point. Where the shrinking is done by spinning, the maximum shrink is limited by buckling and the skill of the operator. In shrinking in the press, longitudinal as well as circumferential buckling may occur, and to avoid longitudinal collapse it is sometimes recommended that the angle between the shrunk portion and the side wall should not exceed 45 deg. Where considerable contraction is required the reduction is made in steps of 5 to 15 per cent., and to avoid buckling and body collapse a mouth anneal is sometimes given, or the mouth may be heated and then formed while hot.

SHRINK FLANGING

The operation of shrink flanging (Fig. 11) may be done in a normal press or in a rubber die press, and consists of flanging convex parts, so that the material in the flange has to be shrunk or compressed. The punch is of metal and the die may be of rubber (Fig. 11*a*) or of metal (Fig. 11*b*) with or without a blank holder for controlling wrinkling (Fig. 11*c*). If a blank holder is used true shrinking occurs and the depth of flange is limited only by the ductility of the metal in deep drawing, as this is a deep-drawing process (Section IV, to be published later). In rubber-die pressing with parts of normal dimensions, no true shrinking (i.e., compression without buckling) can be obtained. When such a shrink flange is formed, wrinkles at first appear and are flattened out later by the high pressure of the rubber. The amount of shrink obtainable depends therefore on the final pressure of the rubber. Dorn, Thomsen and Cunningham[7] have obtained values of limiting shrink of 4 to 7 per cent. on a number of alloys in sheet 0·036 in. thick, using ½ ton per square inch rubber pressure. Values can be estimated with sufficient accuracy for other alloys; slightly higher values are obtained with higher rubber pressures, especially on soft materials. The maximum shrink varies a little according to gauge, the thicker gauges giving higher figures. When a slight amount of wrinkling, to be removed by a further operation, is allowable, the above values may be increased to 6 to 10 per cent.; at higher shrinkages wrinkling is so severe as to be removed only with the greatest difficulty. If bearer or slipper blocks (Fig. 11*d*) are used the support given to the flange reduces wrinkling and much greater shrink values, of the order of 10 to 25 per cent. shrink, can be realised. Methods of removing slight wrinkling include hammering, machine shrinking, or the use of metal (for example, "Cerrobend") wedges. In the latter case the part is formed and the wedges are then placed in position between the flange and the bearer block and pressure is applied, thus removing the wrinkles. When a segment only is being formed the free ends do not shrink, so that if the segment is less than about 60 deg. the effective shrinkage is reduced and higher flanges can be obtained. Various devices are used to avoid wrinkling, such as cut-outs to reduce the segment angle, or crimping to absorb the excess material at suitable points.

To be continued

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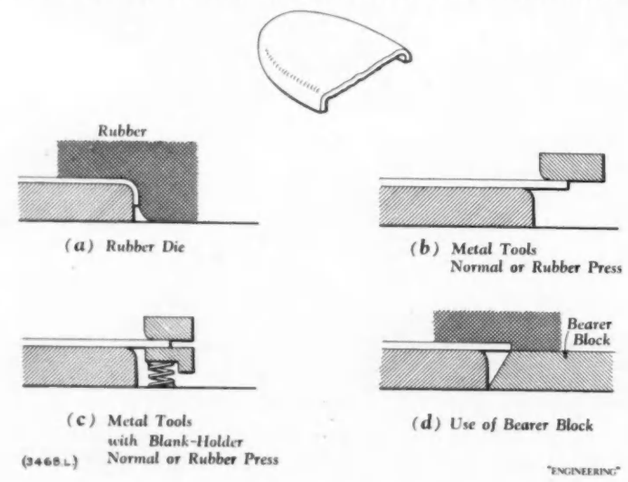
Rubber
(a) Rubber Die
(b) Metal Tools Normal or Rubber Press
(c) Metal Tools with Blank-Holder Normal or Rubber Press
Bearer Block
(d) Use of Bearer Block

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Fig. 11 Shrink flanging.

FABRICATION OF NON-FERROUS METALS

Advances in Welding Corrosion-Resistant Alloys

The great advances that have been made in recent years in the welding of non-ferrous metals have increased the practicability of the use of corrosion-resistant alloys in such vessels as heat exchangers. To give publicity to some of the present possibilities, Imperial Chemical Industries, Limited, arranged a short symposium on the subject to which some 200 interested parties were invited. Short papers were presented by five speakers, and the meeting included a discussion and some demonstrations. Speaking on the possible advantages of seal-welding the tube ends to the tube plates of heat exchangers, Ing. L. J. P. Smulders (N.V. de Bataafsche Petroleum Mij.) gave four main advantages of welding as against expanding. These were: a better guarantee of permanent tightness; easier re-tubing as the weld can be milled away and the tube withdrawn without damage to the end; the tube end plate and tube could be of the same hardness as there were no expansion forces; and bi-metallic tubes could be used. Against these were the need for skilled labour; some limitation of materials; slight increase in cost; and the need for subsequent reaming of the tube end to remove weld splashes. Two applications for which welding had been used were a cooler for a mixture of oil and hydrogen using sea water as a coolant and an ammonia cooler also using sea water. The first was in a reactor effluent system and hair-pin tubes of cupro-nickel were welded to a steel tube plated with cupro-nickel, and in the second bi-metal (cupro-nickel/steel) tubes welded to a cupro-nickel clad tube plate.

The next speaker was Mr. E. D. Dolan (British Petroleum Company, Limited) who considered the case of condensers cooled by sea water, particularly the effects on the channel ends. Corrosion, particularly galvanic corrosion, was the chief enemy here and three remedies were offered. First, coatings could be applied, but these could give false security for a very small penetration might give rise to a heavy action; second, cathodic protection could be used, and this was very effective if the proper techniques were followed with care. Third, non-ferrous metals could be used either as solid or as linings.

Mr. R. H. Meeker (Caltex Services, Limited) spoke of the experience his firm had had with different materials for floating head covers. Starting with a cast iron cover, lining with lead, with brass or sheet bronze had been abandoned, and cathodic protection proved inconclusive. A Monel lining stood up well, but unfortunately transferred the attack to the tube ends. Some success had now been reached by using 70/30 copper-nickel which could be fabricated by welding using a shielded arc technique. The choice of copper alloys was the subject on which Mr. W. H. L. Hooper (I.C.I. Metals Division) spoke. In general, the stress values laid down in the code of the Tubular Exchanger Manufacturers Association were followed. Eleven alloys were listed, and to these might be added the bi-metallic combinations for tube plates.

The final speaker was Dr. D. C. Moore (also of I.C.I. Metals Division), who dealt with the choice of welding systems. Three methods were considered as being most appropriate to non-ferrous metals—metal-arc, shielded tungsten arc and shielded self-adjusting arc. It was generally agreed that the welds made by the first were not of as good quality as when the other two were employed, but the method could be used in some situations where the others were impossible. First consideration of choice must be given to the materials and the service required of them. Thick plates suggested the self-adjusting arc, thin ones the tungsten arc, particularly where access to the joint was good. Poor accessibility indicated the metal-arc process.

The conference concluded with a lively discussion under the chairmanship of Dr. N. P. Inglis; about 20 speakers took part.

The Engineering Outlook—12

GENERAL AND CONSTRUCTIONAL ENGINEERING

CONTINUED BATTLE FOR EXPORTS

The final article in the Engineering Outlook series is an opportunity to review the fortunes of the engineering industry over the past year in the light of information published since the first article appeared in January, and also to cover certain sections of the industry which have not been the subject of previous articles. For the industry as a whole, the outstanding feature of 1955 was the record level of production achieved and the extent of the advance over the previous year, in which production was already higher than in any preceding year. On the basis of 100 for 1948, the index of production for engineering, shipbuilding and electrical goods stood at 153 for 1955, compared with 140 in the previous year and 129 in 1953. In spite, therefore of the increase in Bank rate early in 1955, and the subsequent restrictions on hire purchase and other forms of credit, the rate of increase in production was slightly higher between 1954 and 1955, than between the two previous years. The index moreover continued to rise throughout 1955, though in the fourth quarter of the year it stood only 6 per cent. higher than in the corresponding period of 1954, compared with over 11 per cent. higher in the first quarter.

The index of production for vehicles, again on the basis of 100 for 1948, has shown an even more marked increase than that for engineering as a whole and stood at 172 for 1955, the highest figure recorded for any industry with the exception of chemicals, for which the 1955 figure was 177. The recession in private car output must therefore be viewed in relation to the exceptional expansion which has taken place in the vehicle industry over the last three years.

The object of the financial restrictions imposed during the past year has, of course, been to direct production from the home market to export markets rather than damp down production as a whole, and it is therefore interesting to see how the engineering industries as a whole have fared in export markets. Exports of machinery, other than electrical equipment, rose by about 12½ per cent. from £409·4 million in 1954 to £460·0 million in 1955; of electrical machinery, apparatus and appliances by just under 13 per cent., from £170·2 million to £191·9 million; of road vehicles and aircraft by just under 10 per cent., from £307·5 million to £337·5 million; and of ships and boats by 5 per cent., from £51·0 million to £53·6 million; while exports of railway vehicles declined by 9 per cent., from £44·3 million to £40·5 million. With the exception of the last two categories these figures taken by themselves appear very satisfactory, but they are much less so when compared with exports from competing countries, particularly Germany, Japan and the U.S.A.

Taking all manufactured goods together the British share of total world exports (from the 11 main manufacturing countries has) declined from about 25 per cent. in 1950 to 20 per cent. in 1955. To some extent this can be regarded as a natural result of the rehabilitation of German and Japanese industry, but it is significant that the U.S. share of world exports, which had also declined between 1950 and 1954 (though to a smaller extent than the British), increased again in 1955. The rise in total British exports in 1955, though substantial, was less than that in world trade as a whole. The export position in the main branches of the engineering industry has been discussed in previous articles and a number of examples have been quoted of contracts lost to German and Japanese competitors, e.g. in the case of locomotives and rolling stock.

Exports of the main categories of engineering products not already considered are shown in the table on page 334. After three years of relative stability the total of these categories showed an increase of 18·5 per cent. in 1955, which is substantially higher than the increase for the engineering industry as a whole. The main categories contributing to this increase were excavating and similar digging machinery (though in this case the increase followed a fall in exports in 1954), furnace plant, laundering and dry-cleaning machinery, office machinery, packing machinery, portable power tools, sewing machines, ball and roller bearings and scientific instruments. If comparison is made with 1951, exports of excavating machinery, office machinery, ball and roller bearings and scientific instruments have shown a particularly impressive advance.

MECHANICAL HANDLING AND EARTH MOVING PLANT

The steady rise since 1952 in the output of mechanical handling equipment shown in Fig. 1 reflects the increasing pressure of manpower shortage throughout British industry and there is undoubtedly scope for still further expansion in this field. Considering the three categories shown by value (conveyors and elevators, cranes, and other mechanical handling equipment) output has increased from a monthly average of £4·0 million in 1952 to £5·3 million in 1955, and this has been accounted for almost entirely by increased deliveries to the home market. The credit squeeze appears to have had very little effect on manufacturers in this field and the volume of orders on hand at the beginning of 1956 is reported to have been higher than ever before. The manufacturers of conveyors for light industry in particular are likely to benefit from the trend towards the introduction of fully or semi-automatic operation in the process industries. An important development has been that of long-reach fork-lift trucks which enable greater use to be made of storage space, and manufacturers of fork-lift trucks have undertaken considerable expansion to capacity.

That there is a very large potential market for fork-lift trucks and other materials-handling equipment was brought out in an action pamphlet issued by the British Productivity Council last year. It was stated that of a total wage bill in British manufacturing industry of £2,500 million, between one-sixth and one-third could be attributed to handling costs. Moreover, 28 per cent. of accidents causing loss of time in industry were stated to be due to inefficient handling, and to have cost £19 million.

A growing and comparatively modern section of the conveyor industry is the manufacture of escalators or moving staircases. The first to be installed in this country was at Earl's Court station about 45 years ago and their use has since extended to department and chain stores, exhibition halls and many other places where advantage can be taken of their ability to move large numbers of people quickly from one level to another. In the United States of America the use of escalators is having an important influence on the layout of large commercial buildings and the use of building space in urban centres. It has been found that by the provision of escalators certain services such as banks, insurance and Government offices can conveniently be located on the first instead of on the ground floor, since the use made of these services is not dependent on displaying them to the public, and the ground floor sites can then be let at higher rents for shops and other purposes where such display is important. Export markets for escalators are developing particularly in South Africa, Australia, New Zealand and some European countries.

With industrialisation going ahead in many countries there has been a strong export demand for earth-moving machinery, but keen competition has been experienced, in some cases from countries which have not formerly been strong competitors of the British engineering industries. At the Yugoslav International Trade Fair held at Zagreb in September, 1955, a range of Russian earth-moving equipment was displayed and attracted considerable attention. This included a power shovel of 1½ cub. m. capacity, mounted on tracks and powered by a 120 h.p. Diesel engine also of Russian manufacture. Another Russian exhibit was a Diesel-engined dumper truck of about 20 cub. yd. capacity for the removal of overburden or haulage of minerals in open-cast mines. The U.S.S.R. is of course particularly interested in the Yugoslav market and is encouraging exports to that country by means of loans, but if success is achieved with the current five-year plan it may not be long before general Russian competition is experienced in a wide range of engineering products. Fig. 2 shows United Kingdom outputs of civil engineering and contractors' plant over the last four years.

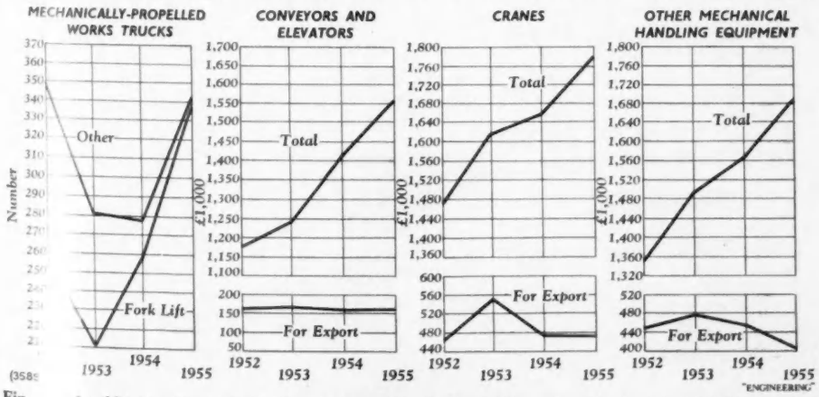

Fig. Monthly average output of mechanical-handling equipment made in the United Kingdom during the past four years.

IMPROVED BICYCLE OUTPUT

As shown in Fig. 5, there was a further increase in bicycle output in 1955 but production has still not regained the level of 1952. The main reason for this was the sharp fall in exports in 1953 which has not yet been made good in spite of increases in exports in each of the years 1954 and 1955. Home demand has increased steadily over the last four years. The extent of the long-term expansion in this industry can be gauged from the fact that Raleigh Industries, the largest producing unit, have a production capacity about four times that of pre-war and are adding a further 40 per cent. The immediate outlook, however, presents several causes for anxiety, including rising costs, credit restrictions in the home market and the increase in August, 1955, of the United States

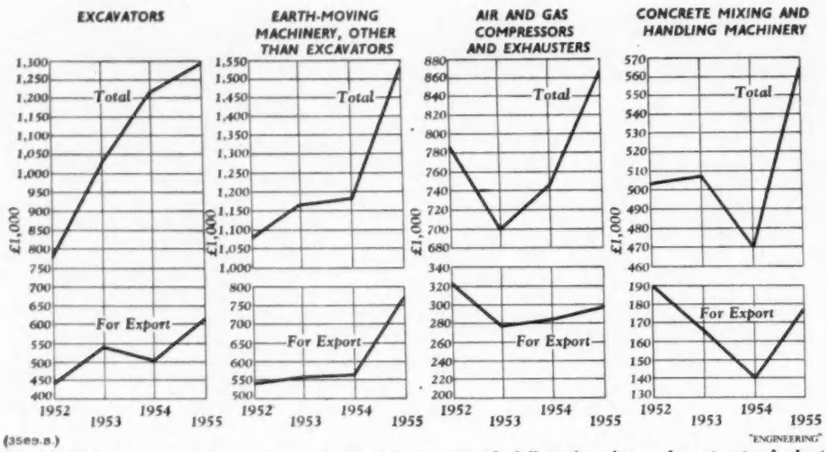

Fig. 2 Monthly average outputs for the last four years of civil engineering and contractors' plant in the United Kingdom.

tariff. The United States has for the last few years been the largest individual market for British bicycles and in 1955 took 538,329 cycles out of total exports of 2·4 million. This represented a slight increase over the 534,390 cycles exported to the United States in 1954, but the higher tariff had been in force only for the last four months of the year and exports to the United States in December, 1955, amounted to only 44,307 compared with 77,908 in December, 1954.

The tariff increases followed the recommendation of the Tariff Commission: a rise from 15 per cent. *ad valorem* to 22½ per cent. in all cases except the large-wheeled lightweight machines, where the increase was from 7½ per cent. to 11¼ per cent., though the Tariff Commission had recommended an increase to 22½ per cent. in this case also. President Eisenhower stated at the time of the increase that the expansion of the United States market for large-wheeled lightweight cycles had largely resulted from the efforts of foreign producers and American importers and that the American industry manufactured almost no bicycles of this type. As regards other types of cycle, however, he was satisfied that increased imports constituted a serious threat to the American industry and that the latter was showing encouraging signs of striving to meet this challenge. The background to this tariff increase was that American production, which had remained fairly steady at about 2 million cycles a year in the five years up to 1954, declined in that year by about 25 per cent. and in the first six months of 1955 production amounted to only 546,000 machines. In spite of the final concession in respect of large-wheeled lightweight cycles, constituting the bulk of the United States imports, the decision to increase the tariff raises considerable anxiety regarding the future of the dollar-export drive in general, particularly since the number employed in the American cycle industry in 1953 was only 3,954 and none of the manufacturers was exclusively devoted to the manufacture of bicycles.

Although there does not appear as yet to have been a large-scale increase in Japanese competition—which was very serious before the war, particularly in Far Eastern and African markets—competition is nevertheless increasing in export markets. The Federation of Malaya, for example, which took 88,000 cycles from the U.K. in 1955, has arranged to import from India, the initial order being for 35,000 cycles. India is itself an important market for British cycles, taking 146,000 in 1955, and as long as Indian capacity is insufficient to meet home demand, any loss in British exports to Malaya is likely to be made up by increased sales to India. Although Indian production is increasing, there is a very large potential market for British cycles in India and neighbouring countries provided the general standard of living can be raised more quickly than the Indian capacity to produce cycles.

The increase in British exports in 1955, was well spread over a large number of markets and in the long run it may well prove possible to make good any decline in exports to the U.S.A. This can only be achieved, however, if the present trend of rising costs can be halted. Short-time working was introduced in March, 1956, for some employees of the Hercules Cycle Company due to an easing of export orders and further cost increases can only intensify this.

Output of motor cycles in 1955, at a monthly average of 14,810 was slightly below the figure for the previous year, namely 14,970. Home sales increased but production for export fell from a monthly average of 5,860 in 1954 to 4,990 in 1955. British motor-cycle manufacturers have been criticised for undue conservatism and delay in introducing the continental type scooters and mopeds, but the first British models were on sale during 1955 and others are being introduced for the 1956 spring trade. British imports of motor cycles and motor tricycles (including parts and accessories for mechanically propelled road vehicles) amounted to £6·2 million in 1955, compared with £4·3 million in the previous year and it will be interesting to see in the current year how far British manufacturers can not only supply the home market (there are approximately 60,000 of these scooters in use in this country) but also develop exports. One model has of course, been manufactured in the country under licence, but the balance has been supplied by continental manufacturers.

OFFICE MACHINERY AND SCIENTIFIC INSTRUMENTS

As shown in Fig. 3 the output of typewriters, accounting and similar machinery, and other office machinery, constituted a record in 1955, and exports have also shown a steady expansion over the last four years. A feature of the last few years has been the establishment in this country of new factories by American and Italian producers, but in spite of this most of the older established British-owned companies have continued to expand production. U.S. subsidiaries which produce electric typewriters have reported a very rapid increase in demand for this type of machine; in one case production rose by 60 per cent. in 1955. Demand for other types of office machinery, including dictating machines, has been stimulated by the manpower shortage and production is expected to continue at a high level throughout the current year.

A start is being made on the large-scale manufacture of electronic computers and it was reported in November, 1955, that 40 or 50 would be made in this country during 1956, though the full rate of production will not be reached by most manufacturers until 1957. At a cost of several thousand pounds each, the orders on hand at the end of 1955 for some 100 machines were stated to be worth more than £3 million. A substantial proportion of these orders is for export and some of these machines were completed in 1955.

Over the whole range of electronic equipment it is estimated that sales in 1956 may exceed £250 million, of which about one-sixth will be accounted for by exports, and the expanding demand for this type of equipment may more than counteract the expected fall in demand for domestic radio and television receivers. In addition to the new electronic computers, mentioned above, at least two electronic machine-tool control units will be introduced during the year as well as a special data-processing system designed for controlling the operation of factory plant or undertaking office analyses. Another unit will automatically undertake the analysis of samples of industrial chemicals to a high degree of sensitivity.

INSTRUMENTS

Attention was drawn in these articles last year to the growth in output of the British instruments industry, and it can be seen from the table that

TABLE.—U.K.: EXPORTS OF SOME INDUSTRIES, CLASSIFIED AS "GENERAL ENGINEERS." (Value in £1,000.)

—	1950	1951	1952	1953	1954	1955
Air and gas compressors and exhausters	3,824	4,353	5,284	4,986	5,157	5,388
Boot and shoe machinery	715	718	902	885	958	1,162
Cement-making machinery	1,693	1,506	1,796	1,445	988	1,134
Centrifugal drying machinery	401	566	769	817	709	879
Concrete-mixing machinery	1,013	1,182	1,389	1,301	1,117	1,597
Condensers	511	653	599	788	890	758
Cranes, hoists and other lifting machinery	3,284	8,751	10,754	12,234	11,836	11,682
Dairy machinery	1,828	1,915	1,883	1,122	1,382	2,009
Excavating and similar digging machinery	7,862	9,838	14,250	16,111	14,893	18,907
Fans, power-driven	1,483	2,039	2,515	2,715	2,574	2,763
Food preparation and sterilising machinery	4,581	4,154	5,011	4,538	4,238	4,527
Furnace plant	1,304	1,070	1,518	1,473	1,404	2,999
Gas and chemical machinery	3,186	2,331	2,207	2,229	2,486	2,801
Grain-milling machinery	2,465	2,122	2,477	2,059	2,040	2,283
Hydraulic machinery	504	1,260	1,357	913	789	1,255
Laundering and dry-cleaning machinery	5,119	8,899	7,113	6,030	6,757	7,488
Lawn mowers	1,447	1,831	1,651	1,542	1,827	2,034
Office machinery	5,966	9,249	9,681	11,094	12,192	14,790
Packing, packeting and labelling machinery	2,797	3,117	3,386	2,883	3,523	4,820
Portable power tools	2,998	3,544	3,825	3,794	4,174	5,313
Printing and book-binding machinery	10,001*	9,808*	9,300	8,509	9,061	9,874
Pulp and papermaking machinery	2,085	2,081	3,204	4,119	4,086	4,068
Pumps	8,326	9,776	13,299	13,496	13,250	13,795
Road rollers	1,200	1,077	1,570	1,610	1,658	2,086
Sewing machines and parts	5,999	7,024	8,315	7,297	8,046	9,699
Sugar-making and refinery machinery	2,363	2,327	2,819	2,426	3,656	3,271
Tobacco and cigarette-making machines	1,945	2,419	2,880	3,385	4,273	3,842
Weighing machinery	1,306	1,514	1,646	1,606	1,495	1,708
Welding machinery	2,420*	2,714*	2,365	2,421	1,797	1,895
Woodworking machinery	2,083	2,200	2,517	2,077	1,875	2,128
Ball and roller bearings	2,533	2,471	3,176	3,620	3,864	4,523
Opthalmic instruments	565	854	648	698	794	780
Medical and surgical instruments	2,187*	2,491*	1,861	1,776	2,071	2,282
All other scientific instruments	6,850	7,807	9,243	9,968	11,018	12,274
Clocks and watches	1,376	1,348	1,123	1,050	1,342	1,604
Total	104,220	125,009	142,333	142,917	141,220	[illegible]418

* Not comparable with figures for 1952, 1953 and 1954.

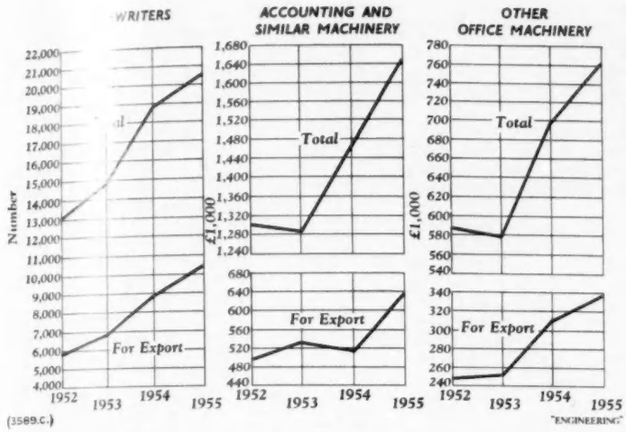

Fig. 3 Office equipment made in the United Kingdom since 1952. The figures are the monthly average of output for the year indicated.

exports have risen steadily since 1951. Sir Norman Kipping, Director-General of the Federation of British Industries, opening a display of instruments at SIMA House in February last, said that the output of the industry now amounted to £60 million, of which a quarter is exported. The display, organised by the Scientific Instrument Manufacturers Association is intended to provide a centre where oversea visitors can see a representative selection of instruments made in this country. The rate of expansion of the industry has been rapid, and it was stated at the fourth annual conference of SIMA in November, 1955, that output in 1955 showed an advance of about 25 per cent. on the preceding year, while some manufacturers had expanded sales by as much as 45 per cent.

In order to facilitate the rapid growth of relatively young industries of this type it is important that as high a degree as possible of mobility of labour should be maintained and that there should not be too rigid an approach to problems of redundancy of labour in other industries, whether this arises from contracting demand or from improved production efficiency. The evolution of a sound policy to deal with problems of labour redundancy and effect a smooth transfer of labour from one industry to another may well prove one of the major problems facing British industry in the next few years. It would do much to foster a realistic approach by the trades unions to the problems of increasing automation throughout industry and to improvement in productive efficiency generally. No-one would quarrel with the claims of the retiring President of the Amalgamated Engineering Union at the opening session recently of the Union's annual delegate conference, that the profit derived from "this progressive and threatening method of production" must be shared with the worker (though they might disagree with his definition of automation, which in its widest sense represents perhaps the most important method of reducing costs and keeping British industry competitive in export markets). Progress will, however, be seriously hampered if the Union's approach is to be that which found favour on the second day of the conference, namely that there shall be "no automation without consultation" and that workers displaced shall be retained until other work has been found for them.

The conference later approved a motion, against the advice of the executive, pledging support to shop stewards and members who resisted redundancy "at the point of production." Although under present conditions there is little likelihood of redundant labour being unable to find alternative employment, within a reasonable time the human problems associated with labour transfer are considerable and in many parts of the country are increased by a continued shortage of housing. It may be hoped that this problem will receive further attention by the National Joint Advisory Council which, as announced last week, is to tackle the problems of the efficient use of manpower throughout industry. This work is, however, primarily concerned with what were formerly known as "restrictive labour practices" and it has been agreed that each section of industry should be asked to tackle the problem in the light of its own special needs and circumstances.

CONCLUSION

Considering the outlook in the coming year for the engineering industry as a whole it is difficult to assess the full effect of the anti-inflationary measures so far taken. While the recession which has already taken place in some branches of the industry must be expected to continue for some time, and the industry as a whole cannot expect a continuance of the rapid increase in production which has characterised the last two years, 1956 may well see a small advance in production compared with 1955. The wage increase agreed in March of 12*s.* 6*d.* per week for skilled men and 9*s.* 6*d.* per week for unskilled, representing an increase of about 8 per cent. compared with the original claim for 15 per cent., is probably slightly higher than is justified by increased productivity, but should not be large enough to affect seriously export prices. The German engineering industry is also facing inflationary pressure and it is possible that British manufacturers may be able to retain their competitive position in export markets. In the longer term it is not encouraging that the delegates to the annual conference of the A.E.U. have already instructed the executive to press for a further substantial pay rise but it appears that this question will have to be discussed with representatives of other unions at the annual conference of the Confederation of Shipbuilding and Engineering Unions in August, and whatever the outcome, is unlikely to affect the position this year. Much will depend on the extent to which foreign competitors, particularly Germany and Japan, are affected by inflation.

At the best therefore the current year may see some diversion of production to export markets at the expense of the home consumer, and if this can be achieved the stage would be set for a further advance in production in 1957. There have, however, been many complaints recently from oversea countries that even where British manufacturers succeed in securing orders for machinery and vehicles, the after-sales service and supply of spare parts is inadequate, particularly in relation to that provided by German competitors. Even where prices are competitive the long-term effect of this can only be loss of valuable export markets. It may be hoped that the credit squeeze at home will compel manufacturers to pay more attention to this aspect of the export trade, since with the present balance of payments position any decline in exports cannot be made good by increased home sales but will be accompanied, owing to inability to purchase the necessary raw materials, by a decline in production as a whole.

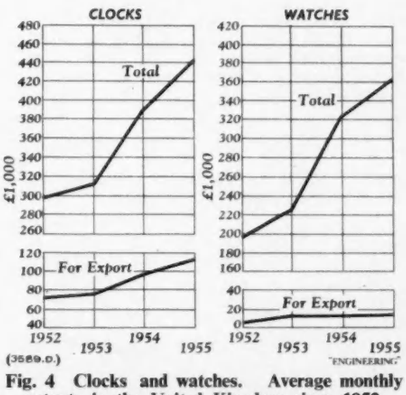

Fig. 4 Clocks and watches. Average monthly outputs in the United Kingdom since 1952.

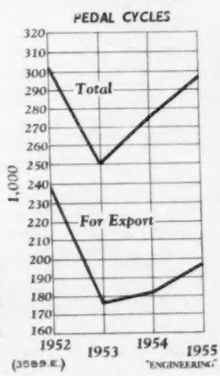

Fig. 5 Monthly average output of cycles in the United Kingdom since 1952.

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VACUUM SINTERING OF HARD METALS

The exceptional qualities of cemented carbide for the rapid machining, heavy roughing and fine finishing of a variety of materials are achieved only by exercising the greatest control over the material during manufacture. Wm. Jessop and Sons, Limited, of Sheffield, who have supplied Cutanit cemented carbides for a widening number of applications for nearly 20 years, have recently issued brief particulars of the method used by the manufacturers, Metro-Cutanit, Limited, Grappenhall, near Warrington, Lancashire, in the sintering of this product. Of importance in the preparation of the material are strict control over the grain size and carbon content of the hard metal; moreover, during the sintering operation fine temperature control and freedom from contamination by oxygen and nitrogen are necessary. These considerations apply not only to the manufacture of the finished sintered carbide but also to the production of its constituent parts, particularly in the preparation of the carbides of titanium and tantalum and the mixed carbides of tungsten, titanium and tantalum used in the steel-cutting grades.

An early realisation of the necessity for this control of atmosphere and temperature led the firm to the introduction of vacuum electric induction furnaces in 1932, and these furnaces became, and have since remained, the standard equipment for the manufacture of the hard metals. The use of vacuum furnaces for sintering has several substantial advantages, namely, there is no possibility of contamination, the furnaces are easy to control to a fine degree, and the continual reproduction of the ideal manufacturing conditions is comparatively easy to attain by means of instruments.

Messrs. Jessop's supply cemented carbides, mainly in the form of tips and tools, to the extent of many hundreds of thousands of pieces a year. These are employed in the high-speed turning, milling, planing and boring of metals and alloys of the greatest density and hardness, and the working of glass, ceramics, rubber, paper, wood and other materials.

Book Reviews

TOWARDS NEW ROADS

Concrete Roads: Design and Construction. Prepared by the Road Research Laboratory. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (25*s.*)

Among industrialised countries Britain has the distinction of possessing one of the largest road research organisations and one of the smallest mileages of modern roads. It is not suggested that these two facts are in any way related as cause and effect, but apart from being an indication of the peculiar spot-blindness of successive Governments in regard to road problems, the size and efficiency of the Road Research Laboratory and the smallness of our past and present programmes of road construction must also have an effect on the thinking of both research workers and practising road engineers. This effect is particularly noticeable in regard to concrete road construction, for this is essentially the method for new road works and does not normally provide the opportunity for practice given by the repair and re-surfacing of roads built in other ways.

It is only natural that the new book on concrete road design and construction published by the Road Resesearch Laboratory should show some evidence of the absence of recent full-scale construction experience and it was, no doubt, wise for the team of authors, led by Mr. F. N. Sparkes, to avoid an attempt at producing a complete manual of concrete road construction and to confine their book to those aspects that have been the subject of investigation at the Road Research Laboratory. The result is that what the book loses in breadth by this limitation it gains in authority.

The industrial research worker is rather like a doctor in that his experience tends to contain an undue proportion of difficulties and defects, and this natural bias—without, in this case, the counterbalancing influence of a healthy road construction programme—has given the book a slight air of pessimism and an appearance of concentrating on faults. The natural conservativeness of a Government Department also adds its effect, showing as a tendency towards caution in describing the merits of any particular process, and towards positiveness in the wording of warnings. This is, however, a superficial effect and the bulk of the book is composed of solid facts, well established and clearly presented. In fact, the study of defects has given a great amount of valuable information useful in assessing the performance of older roads and has provided data on which the design of new roads can be based. As a result, the chapters on design are some of the most valuable parts of the book for they give not only a good account of the various causes of stress in concrete roads but also a simple and practical method of design based on performance.

The design of road slabs by means of an analysis of stresses, as is normally done in connection with other types of structure, is a difficult process and requires assumptions to be made about the properties of the supporting foundation and about the external loading and temperature conditions that are seldom realised in practice. Nevertheless, a great amount of research and theoretical study on road-slab design has been undertaken in several countries and the book gives a good and useful account of this background information. However, even when all the available theoretical data have been collected, the accuracy of the final design is still limited by difficulties of converting traffic loads into equivalent static loads and of combining temperature and loading stresses.

In order to overcome this problem the Road Research Laboratory have made a survey of many existing roads and have correlated their performance with theoretical analyses of stresses. As a result of this work it has been possible to classify a wide range of soils into conveniently few groups and to give the thickness of concrete slab necessary to carry a range of given densities of traffic. Design is therefore reduced to looking up the appropriate slab thickness in a table. It is probably only in extreme conditions that the accuracy obtained by this method would not be well within the limits obtainable by a much more elaborate method.

The only danger in using a method of design of this kind is that its very simplicity makes its application an almost automatic process, requiring little or no thought on the part of the user, and it may lead to something approaching a standard design that may not be the best in any particular situation. It is greatly to be hoped that in the interests of economy in construction the Road Research Laboratory will continue with the collection of data and with their research into design.

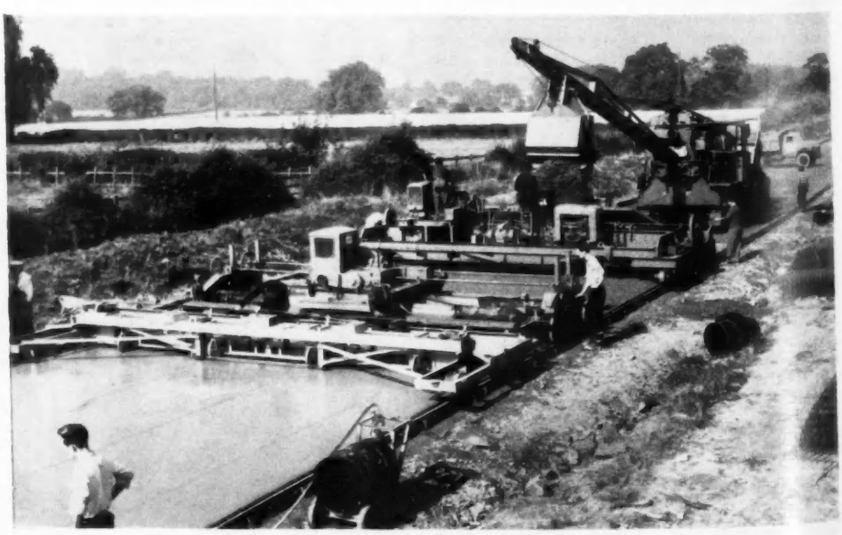
It is natural that a book of the size and complexity of the one under review should take some considerable time to produce and it is, therefore, no surprise to read in the foreword that the text was completed in December, 1954. Since that date there has been almost no new concrete main-road construction in this country and one would, therefore, expect that the book would represent completely up-to-date views. In fact, this is not quite true, for in one or two important respects the past year has produced some important changes in thought about concrete road construction. These changes have been brought about by several factors, among which the most important are the appreciation of the lessons to be learned from road construction in other countries, the introduction of the joint-sawing technique, a change in the requirements for airfield runways in regard to riding quality that brings them into line with those for roads, so making airfield construction experience much more useful in road work, and last, but by no means least, the application of the results of the research described in the book.

The effect is that, writing in 1954, the authors could say with some justification—" The riding quality of concrete roads laid by mechanical methods is not as good as . . . that of the best bituminous carpets laid by machine," whereas it is now clear that on the Continent long lengths of concrete roads are being laid with a riding quality at least as good as that achieved with any other material. Recent work in Britain, on both roads and runways, indicates that even better results can be achieved.

One of the main causes of this improvement has been the introduction into this country of the technique of sawing joints after the concrete has hardened. This process has been used in the United States of America for some years and is also widely employed in several European countries. Until recently, however, it has generally been considered by British road engineers and the Road Research Laboratory to be too expensive. But the manufacture here of improved machines and the establishment of the correct cutting technique and form of abrasive to use has made the process little more expensive than other methods of joint construction. The result is that not only has the joint been virtually eliminated as a cause of surface irregularity but it has also been made less noticeable and neater in appearance.

A further advantage of the process is that with this removal of the major objections to joints, the road designer is given much greater freedom in making a choice of slab length and can use as many joints as are required for economy in materials and construction.

The effect of airfield construction on road making has already been mentioned. In the past the differences between the two types of work have been so great that experience in one field has been of little use in the other. Substantial differences, for example, in slab thickness and hence in the quantities of concrete that have to be laid still remain, but in some respects similarities are growing up that will make experience in runway construction valuable to the road engineer. It is now becoming clear that the modern high-speed aircraft requires a runway with a riding surface equal to that of a first-class road in respect of both freedom from irregularity and in skidding resistance. It seems, therefore, that in solving the problems of producing a suitable riding surface (dealt with at considerable length in the book) the road engineer now has a useful ally. As the airfield engineer lays in one year as much concrete as would be required in many years of a major road construction programme, we now have a group of contractors with first-hand experience of the kind required for road construction. When road construction starts on a substantial scale the problem will not be how a construction organisation can be built up, but how an existing organisation can be compressed into the size required by any likely programme. It is to be hoped that the contracts will be made large enough to allow the full efficiency of the British airfield contractor to be applied, but even if they were as large as that for an airfield the



Construction work in progress on the recently opened Oxton by-pass extension, Nottinghamshire. The plant is of a type previously used for airfield runways. (Photograph by courtesy of John Laing & Son, Ltd.)

road c tor would still be faced with the problen dealing with a site many miles long and only out 100 feet wide.

In air construction the normal method is to erect single large batching or mixing plant for the c crete with large stock piles of the various materials located close to the plant. In this way very high rates of output can be obtained. In road works it would probably not be very economical to transport mixed concrete or dry-batched materials for distances greater than perhaps two miles, and on some sites this may be difficult or almost impossible if bridges are not completed before concreting of the road begins.

Until we have experience of road works on a considerable scale it is difficult to forecast whether the solution of this problem will rest with a small and comparatively easily moved batching plant or whether some improved form of transport might be used. In this connection it is interesting to note that in spite of the rapid development of pneumatic-tyred transport of all kinds that has taken place in the meantime, motor-road construction methods in Germany still rely on the narrow-gauge railway track first used when work began in 1936.

In addition to the sections of the book on design, construction, plant and defects that have already been mentioned, there is a valuable section of nearly 150 pages on the properties of cement, aggregates and concrete and on mix design, and a short though not quite so adequate chapter on prestressed-concrete roads.

As would be expected from a Stationery Office publication, the book is well designed and printed, though there is one curious fault in layout—a table which is printed over what should have been two facing pages has become divided by the inclusion of several pages of illustrations—and the binding is of a texture and colour that will quickly show the marks of engineers' fingers. For a book of its quality and size (400 pages, some 120 figures and about 50 full-page plates) it is remarkable value for money.

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NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Electrical Who's Who, 1956-57. Compiled by "Electrical Review." Fourth edition. Published by *Electrical Review Publications, Limited*, and distributed by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (21*s.*)

The new edition of this reference book contains about 7,000 entries giving biographical details of men and women engaged in every branch of the electrical profession and industry. It also includes the names of leading electrical people in various Government Departments. Information in each case is given of the positions and appointments of those included, as well as of their qualifications and professional activities. All the biographical entries are classified in an index under the titles of their companies or other organisations.

Electrical Installation Work: Definitions and Formulae for Students. By F. PEAKE SEXTON. Eighth edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (1*s.* 9*d.*)

The object of this book is to provide the installation engineer with the data and tables necessary for his daily work. It covers definitions, symbols and abbreviations, and the conversion of units. Among other subjects dealt with are cables, fuses, conduits, resistivity, earthing, heating effects, motors, ventilation, alternating current and lamps. It may be regarded as supplementary to the I.E.E. Regulations and Home Office Rules.

Simple Perspective Drawing. By ARTHUR R. BROWN. *Crosby Lockwood and Son, Limited*, 26 *Old Brompton-road, London, S.W.*7. (6*s.*)

Since Piero della Francesca first made use of the vanishing point, the technique of perspective drawing has undergone steady progress until to-day when it is widely used in industry to illustrate products and as an aid to design. Such projections as the isometric, axonometric and oblique, though useful in visualising an item do not give its true appearance, and a perspective drawing may often be more useful, especially when orthographic projections have to be translated for the benefit of the non-technical. This book, which is well illustrated, provides a straightforward introduction to the treatment of parallel and angular perspective, and covers in addition such subjects as the representation of shadows and reflection.

Applied Solar Energy Research. A Directory of World Activity and Bibliography of Significant Literature. Edited by E. J. BURDA. Published for the Association for Applied Solar Energy by *Starford Research Institute, Stanford, California, U.S.A.* (No price given.)

Communications in the field of investigation into solar energy utilisation have been relatively poor, co-ordination of research efforts has been uncertain, and the tendency towards the development of isolated theses and over-concentration on a specific method of approach has been strong. In an attempt to remedy this situation, this volume is presented as a central catalogue of the current status of research on the utilisation of solar energy. It is hoped that the directory and bibliography will assist established specialists in the field to assess the progress achieved so far, and provide those newly entering solar research with a comprehensive statement of the position from which they may advance.

Britannica Book of the Year, 1956. *Encyclopaedia Britannica, Limited*, 11 *Belgrave-road, London, S.W.*1. (84*s.*)

This latest edition of the *Britannica Book of the Year* covers the events of 1955. Notable contributors include Dr. A. H. Willbourn on plastics; Mr. E. W. Golding on the electrical industries; Dr. D. B. Steinman and Professor J. F. Baker on bridges; and Dr. W. H. Glanville on roads. A comprehensive index is included.

Boiler Explosions: Reports of Preliminary Inquiries. Explosion from a Steam-Heated Platen at Commercial Plastics, Limited, Willington Quay, Wallsend-on-Tyne. No. 3379. (9*d.*); **Explosion from a Steam-Heated/Water-Cooled Table at Yatefield Mill, Burnley, Lancashire.** No. 3380. (9*d.*); **Explosion from a Second Steam-Heated Platen at Commercial Plastics, Limited, Willington Quay, Wallsend-on-Tyne.** No. 3381. (9*d.*). *H.M. Stationery Office, Kingsway, London, W.C.*2.

These accidents all emphasise the obvious that any closed vessel to which steam is admitted should be designed for a pressure of not less than that of the steam which is to be supplied. Where the supply is at some higher pressure, arrangements should be made for reducing the pressure to a safe level by means of a reducing valve, properly set and maintained, on the supply line. In addition, a relief valve and a pressure gauge should be provided on the low-pressure side of the reducing valve. Two of these three explosions occurred in the same works at an interval of less than a month, but, fortunately, no one was injured. In the other case, an employee was absent from work for nearly ten weeks, owing to scalds.

The Steam Boiler Yearbook and Manual (V). Edited by R. J. MILLSON. *Elek Books, Limited*, 14 *Great James-street, London, W.C.*1. (42*s.*)

The fifth volume of this year book, the publication of which has been delayed owing to the illness of the former editor, covers combustion appliances; pulverised fuel, oil and gas firing; and systems of automatic boiler control. Information is also given about vertical, locomotive, internal flue, horizontal multi-tubular, waste-heat and water-tube boilers. Further aspects of steam engineering will be dealt with in a forthcoming volume.

Peaceful Uses of Atomic Energy: Proceedings of the International Conference in Geneva, August, 1955. Vol. 2: Physics; Research Reactors. (57*s.*); **Vol. 14: General Aspects of the Use of Radioactive Isotopes: Dosimetry.** (45*s.*) *H.M. Stationery Office, Kingsway, London, W.C.*2.

Two more volumes in the series of 16 covering the Geneva Conference on the Peaceful Uses of Atomic Energy have now been published: Volume 2 dealing with nuclear physics and research reactors and Volume 14 on radioactive isotopes and dosimetry. The first part of Volume 2 is concerned with such special topics in nuclear physics as neutron cross-sections and scattering, and with the problems of nuclear fission; while in the second part a number of research reactors including the United Kingdom DIDO, the Norwegian JEEP, the American MTR, the Russian RPT and a French pile at Saclay, are discussed. Most of the research reactors already completed or at an advanced stage of design or construction throughout the world are covered, and their use and operation outlined. Volume 14 is devoted to such subjects as the application of isotopes in technology and industry and their production; the techniques for handling large and small quantities of radioactive materials; and recent developments in the field of dosimetry. This last section includes descriptions of instruments for the detection and counting of radioactive particles and for general radiation analysis. Volume 2 has 471 pages and Volume 14, 305; both are well illustrated. Volume 3, "Power Reactors," has already been dealt with in these columns.

Taxation of Profits and Income: A Digest of the Reports of the Royal Commission. *Federation of British Industries*, 21 *Tothill-street, London, S.W.*1. (5*s.*)

Taxation on profits and income is a burden which falls with greater or less severity on every person above the bare subsistence level. Many more people are closely concerned in the proposals to reform the structure of taxation than can afford the time to consider the three reports of the Royal Commission on the Taxation of Profits and Income and the two preliminary investigations by departmental committees under Sir James Millard Tucker on the taxation of trading profits and the taxation of provisions for retirement. This F.B.I. brochure summarises without comment, but with reference to the relevant paragraphs, the contents of those five documents which together comprise some 900 pages and constitute a searching examination of the law that extended over six years in all. A brief but competent index to the original volumes and to the digest itself is included.

Mechanism. By JOSEPH STILES BEGGS. *McGraw-Hill Book Company, Incorporated*, 330 *West 42nd-street, New York* 36, *N.Y., U.S.A.* (6.50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (49*s.*)

This book is intended for students in advanced kinetics and for practising engineers. The author begins by pointing out the dual nature of mechanical design: the choice of a mechanical movement and the design of the machine members, and the fact that these two phases affect each other. Factors affecting the design members and the design as a whole are discussed. The classical vector equations of relative motion are used to analyse mechanisms of varying degrees of complexity. By the use of descriptive geometry, these vector equations are applied to three-dimensional motion and graphical solutions in three dimensions are obtained. Analytical methods are also used and space linkages are analysed. Subsequent chapters discuss the synthesis of gear tooth curves and the efficiency of planetary gears; cams; rotary drives; linkages; tension and flexural links; fluid compression links; computing mechanisms; and the control of mechanism. These chapters are abundantly illustrated by practical examples. Another chapter discusses special topics, such as the kinematics of geometrical optics, precision and accuracy, and combinations in mechanism. A special chapter deals with Newtonian mechanics of rigid bodies, using vector notation. Among the new subjects covered are the hydraulic controls of the Packard automatic transmission, and space mechanisms. The final chapter is a repertory of mechanism for the use of designers and to help the student increase his knowledge of known mechanical movements.

Introduction to Agricultural Engineering. By H. F. MCCOLLY and J. W. MARTIN. *McGraw-Hill Book Company, Incorporated*, 330 *West 42nd-street, New York* 36, *N.Y., U.S.A.* (7.50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (56*s.* 6*d.*)

The importance of engineering in agriculture and the relationship of agricultural engineering to agricultural science are explained. Both fundamental and practical aspects are treated, in the latter case entirely from the American point of view. The book is intended mainly for first-year students, but also to serve as an introduction to more specialised work.

Survey on Vibration and Shock Isolation. By J. A. MACINANTE. National Standards Laboratory Technical Paper No. 7. *Commonwealth Scientific and Industrial Research Organization, University Grounds, City-road, Chippendale, Sydney, New South Wales, Australia.* (No price given.)

The prime object of this paper is to offer guidance in the solution of particular vibration problems which occur in engineering works and laboratories. The published information on the theory and practice of vibration and shock isolation is critically surveyed and the main results and conclusions presented. The three sections are devoted to sources, transmission and effects of vibration; fundamental principles and theory; and practical applications. General procedures are suggested for the design of vibration-isolating mountings and various specific cases are considered. An exhaustive list of references to other works on the subject is given.

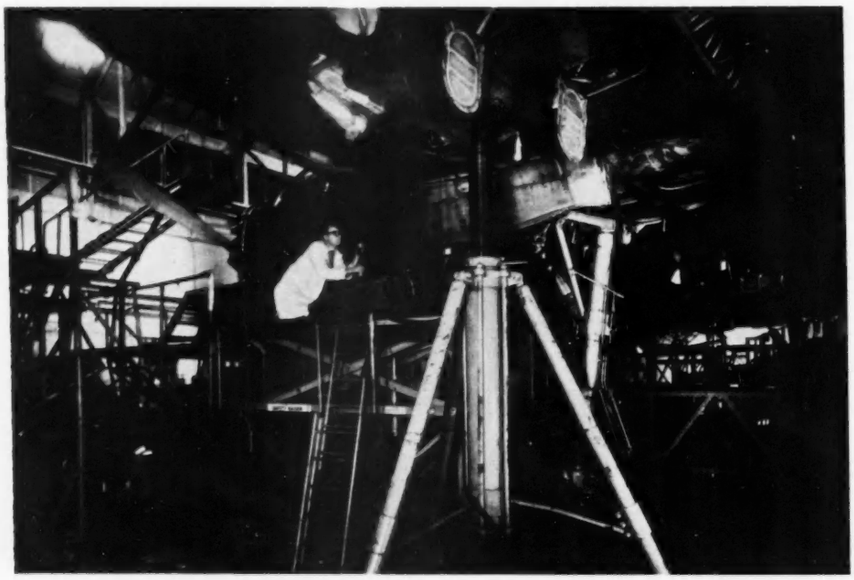


Fig. 1 X-ray examination of the bottom skin of the integral fuel tanks of one of B.O.A.C's Constellation fleet. The 200 kV self-contained Eresco X-ray unit is mounted on a Safety Raiser. The films are laid on the skin surface between stringers inside the wing.

ROUTINE AIRCRAFT INSPECTION BY RADIOGRAPHY

(1) DEVELOPMENTS BY BRITISH AIRLINES AND MANUFACTURERS

Largely as a result of pioneering work in the United States by the Lockheed Aircraft Corporation and the Douglas Aircraft Company Incorporated, the use of X-ray techniques for checking critical parts of the airframe structure during routine maintenance inspections is now a widely accepted practice among many American airlines. During the past year some of the principal European operators have begun to adopt radiographic methods for structural inspections, and in this country both the British Overseas Airways Corporation and British European Airways are in the evaluating stage. Some of the results obtained by the Continental operators are described in the short article below, by Mr. E. W. Kowol. In this first article we propose to outline the developments under way in the British airlines, backed up by certain of the aircraft manufacturers, notably Vickers-Armstrongs, Limited and the de Havilland Aircraft Company Limited.

At certain periods in the life of an aircraft, as called for by the Air Registration Board on the advice of the aircraft manufacturer, the airline operator is required to inspect critical parts of the airframe to ensure that no deterioration of the structure has taken place, in the form of fatigue cracks, corrosion, pulled rivets, etc. Where the critical points are enclosed in a box structure, are located behind cabin upholstery, or are effectively hidden by other components, it may be necessary to dismantle the structure to carry out a visual inspection, clearly an expensive and time-consuming process. It is here that radiography may prove its worth; but it cannot be applied indiscriminately to replace visual inspection, and is better regarded as a supplementary tool.

In order to detect a fatigue crack by X-ray or gamma-ray photography, the position and orientation of the source and film, the wavelength and intensity of the radiation, and the type of film should all be correlated to get optimum definition without interference from other parts of the structure, and a high-contrast result. Thus a satisfactory radiograph of a known fatigue crack in a built-up structure may involve considerable trial and error. In aircraft inspection up to date, structural radiography has been confined to looking for cracks in places where they have already been found previously in aircraft components of the same type, either after the accumulation of many thousands of flying hours, or as a result of long-term full-scale fatigue tests carried out by the manufacturer or a Government research establishment, and for the detection of which the radiographic technique has already been worked out.

The cost of such trial and error procedures is considerable in itself, and the capital outlay on X-ray equipment is fairly heavy, and it is understandable that airline managements do not readily authorise such expenditure unless they are sure that the results will justify it. It is interesting to see the different approach by which the two British airlines have faced this initial financial obstacle: B.O.A.C. have enlisted the services of an experienced non-destructive testing firm, Solus-Schall Limited, to carry out all their radiographic investigations and interpretations for them, whereas B.E.A. have, alone among the airlines, adopted gamma radiography using radioactive isotopes as an initial tool requiring only a fraction of the capital outlay of X-ray equipment but with certain limitations.

EXAMINING CONSTELLATION WING SKINS

Dealing firstly with B.O.A.C., the work that Solus-Schall are carrying out on their Constellation fleet is a typical time-saving application of radiography. On the recommendation of the Lockheed Corporation, each Constellation, as it comes into base for overhaul at the end of 15,000 hours flying, is subjected to X-ray inspection of the bottom skin of the integral fuel tanks between the front and rear spars. To carry out an inspection of this type visually would require the complete stripping of sealant from the interior of the tank and its subsequent replacement, a procedure which would seriously hamper the scheduling of the aircraft.

The radiographic examination is carried out at night, not only to avoid radiation hazards to other maintenance personnel but also because the ground vibration resulting from men at work is sufficient to impair the definition. Because the lead content of the fuel has been found to absorb some of the radiation, the fuel tanks are emptied before examination.

In the case of the Constellation the radiographic technique had already been worked out by Lockheed, and Solus-Schall have merely had to make adjustment to the exposure times to allow for the slightly different speeds of the British films employed. The X-ray apparatus used is a 200 kV Eresco portable unit manufactured by Solus-Schall under licence from Seifert, of Hamburg, which is similar in principle to the Fedrex unit made by Carl Drenck, Copenhagen, employed by the Lockheed Corporation for the work under consideration. The X-ray tube and the high-tension and filament transformers are located in a single oil-cooled tank, weighing in all about 180 lb.; a separate unit, weighing 90 lb., provides for controlling the high-tension supply, the current intensity and the automatic exposure times.

The X-ray films, cut to size, are inserted through an inspection panel and laid on the lower surface inside the wing between the stringers. Two exposures are made at each station, using unscreened Kodak Crystallex and Ilford C fine-grain films; in all about 130 films are used. The X-ray source is mounted on a Safety Raiser (Fig. 1), giving a fixed focal distance of about 1 metre and the exposures are made upwards through the wing. Exposure times are of the order of 40 to 45 seconds at 110–115 kV and 4 milliamperes. The films are processed on site in a mobile dark room.

So far, no cracks have been positively identified. A few of the radiographs have shown small markings that could conceivably have been cracks, but when checked by visual examination (in so far as this is possible without breaking down the structure) these marks have usually proved to be defects in the protective or sealing compound. If there were still any doubt, subsequent radiographic examinations at the next inspection period would indicate, if there were a defect, the rate at which it was spreading. This degree of uncertainty has, however, led B.O.A.C. to regard with some reserve the value of radiographic examination for primary structure, and they feel that at present its advantages are more apparent, economically speaking, on components such as castings, complex undercarriage fittings and propellers—they are periodically examining the hollow-steel propellers of their Constellations by radiography—which can be inspected under laboratory conditions, the resulting radiographs being readily interpreted.

As more experience is gained, it is probable that some of the difficulties in interpreting radiographs of built-up structures will be resolved. One of the present difficulties is that the radiographic specialists are not well versed

Fig. 2 The remote-controlled Pantatron "Bomb" for gamma-radiography with Thulium 170 source.

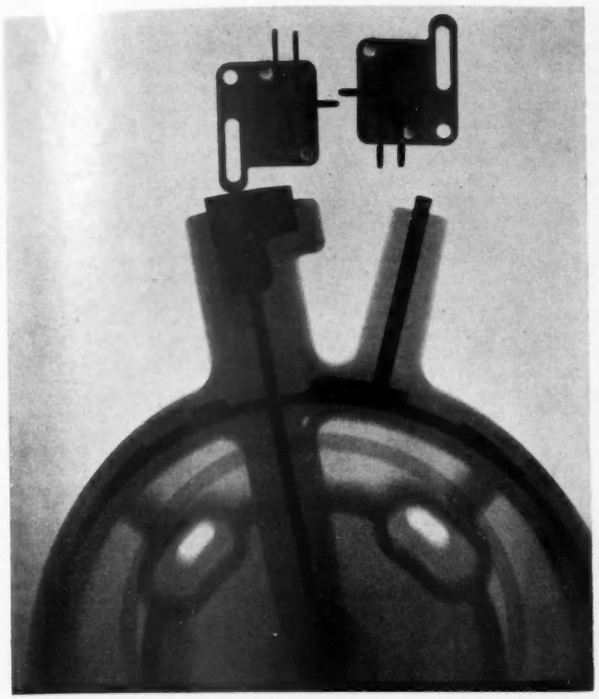


Fig. 3 A print from a gamma-radiograph of a Centaurus distributor rotor and two micro-switches. The condition of the contacts of the latter is clearly revealed without the need for stripping.

in the aircraft structures they have to examine, and conversely the aircraft inspection staff are as yet unfamiliar with radiographic techniques. This, however, is a problem which time, together with close co-operation between all concerned, should solve.

GAMMA RADIOGRAPHY IN B.E.A.

B.E.A. began to take an active interest in radiography some nine months ago with a view ultimately to increasing the utilisation of their Viscount and Elizabethan fleets by cutting down the amount of structural dismantling involved in the major checks. They also had in mind the value of radiography for " panic " inspection at out-stations as well as at base, at short notice, of a whole fleet of aircraft upon the discovery of an unexpected structural defect in a particular machine—a situation which faces every airline operator from time to time. For work of this type portable, easily-handled equipment is even more essential than it is for routine use at base; and in this respect the radio-isotope " bomb " that B.E.A. have adopted is very convenient, being compact, reasonably light in weight (about 40 lb.) and independent of an electrical supply.

Of the radiographic isotopes available from Harwell, Thulium 170, with a half-life of 129 days, is the only source really suitable for use on light-alloy structures, the other commonly used sources having too great a penetration. B.E.A. are using a 300-400 millicurie Thulium 170 source, 3 mm. by 3 mm. in area, roughly equivalent in terms of results to an X-ray source of 85 kV. The source is enclosed in a lead-shielded Teleflex Pantatron " bomb " (Fig. 2), supplied by Inspection Equipment. In this equipment, the source is actually mounted at the end of a lead-filled " pencil " which moves on guide rails available up to 10 ft. long in 2 ft. lengths, and can be extended by remote cable control, thus giving protection to the operator. When not in use, the source is wound into the container which can then be completely closed and locked.

Disadvantages of the radio-isotope source for structural radiography are, firstly, that the penetration is not adjustable to suit the structure under examination; secondly, that owing to the large effective area of the source, in comparison with an equivalent X-ray source, the definition obtained is not so sharp; and thirdly, that considerably longer exposures are required. This last factor has led B.E.A. to the conclusion that gamma radiography will not be practicable for routine use on the aircraft structure on a large scale, and that for such purposes a versatile X-ray unit will be desirable; meanwhile their inspectors are gaining valuable experience in taking, processing and interpreting radiographs. They expect, nevertheless, to find many uses for the Thulium 170 bomb in confined spaces, as well as in the field away from electrical services.

In addition to gamma-radiography of built-up structures, B.E.A. have used their isotope set for the inspection of spares and of castings, during overhaul, and they have found it particularly useful for the examination of the contacts of sealed electrical components. The radiographic print reproduced in Fig. 3 shows a Centaurus distributor rotor comprising a metal conductor embedded in plastics, and two micro-switches. The condition of the contacts of the micro-switches is clearly revealed; here, they are seen to be in good order. This was taken with a Thulium source, having a strength of 310 millicuries, the distance between source and film being 7 in. and the exposure time 15 minutes.

B.E.A. are working in close liaison with Vickers-Armstrongs Aircraft Limited, and expect ultimately to be working to detailed radiographic schedules which Vickers-Armstrongs are proposing to prepare for later models of the Viscount aircraft.

CRACKS, WELDS, RIVETING, CORROSION

Both the de Havilland Company and Vickers Armstrongs have been experimenting for about the past 15 months with the radiography of military and civil aircraft structures in the field, and have now attained a high standard in their radiographic techniques. Among the uses they have found for X-ray inspection are the identification of very small fatigue cracks starting underneath a rivet which could not be revealed at such an early stage by any other means, and keeping a check on the growth of such cracks in service; assessing the quality of riveting and spot welds (Fig. 4); locating loose bolts and rivets, and even occasionally tools and instruments that have been left inside the structure; and checking the lay of cables and piping.

Although it does not appear that radiography is a dependable means of detecting general corrosion in its early stages—it is often easily confused with unevenness in the protective compound at surface intersections—de Havilland have found that they can readily detect corrosion of the pitting type, and Vickers-Armstrongs consider that intercrystalline corrosion can be identified reliably, once experience of each problem has been accumulated. Incidentally one of the earliest applications of the X-ray inspection technique was probably the examination, during the Second World War, of B.O.A.C's Boeing 314 wing structure for intercrystalline corrosion. This operation was carried out for B.O.A.C. in America, but with the passing of the 314's from service their interest in radiography lapsed until some 18 months ago.

Up to the present de Havilland have been working with a 60-70 kV Newton-Victor portable medical X-ray outfit of the tank type, which has limited their structure investigations to comparatively thin wing and tail sections. Their recent acquisition from Inspection Equipment of a 160 kV Fedrex 160 oil-cooled tank set with built-in high-tension transformer will allow them to widen the scope of their operations. The weight of the tube-head tank is 108 lb. and of the control unit 66 lb. Vickers-Armstrongs have been operating with a mobile Pantak 150 kV set in which the high-tension transformer is separate from the X-ray tube. The disadvantage and potential hazard of the high-tension cables connecting the head to the transformer is, they consider, offset by the extremely light weight, 23 lb., and compact size of the head.

Among the difficulties that have been encountered in the application of X-ray photography, we have already mentioned the confusing indications given by protective compounds and paints; folds in upholstery can also be misleading and may be mistaken for cracks. It is the belief of Vickers-Armstrongs, however, that with growing experience in interpretation, aircraft inspectors well versed in the knowledge of their aircraft will, in the majority of cases, learn to distinguish these false identifications. In another category, however, is the problem of wiring bunches located so that they completely block any possibility of radiography. This, they consider, is a problem which the design department will have to bear in mind when laying out the wiring runs in future aircraft. Another problem beyond the scope of radiography is the use of high-tensile steel bolts or anchoring nuts in light-alloy structure, which again completely block any possibility of detecting faults in the light alloy structure.

REDUCING TRIAL AND ERROR IN RADIOGRAPHY

Vickers-Armstrongs have found that the element of trial and error in placing the source and film to obtain a satisfactory radiograph of a known defect in a built-up structure can be greatly reduced by the intelligent use of drawings of the areas considered; where the structure is

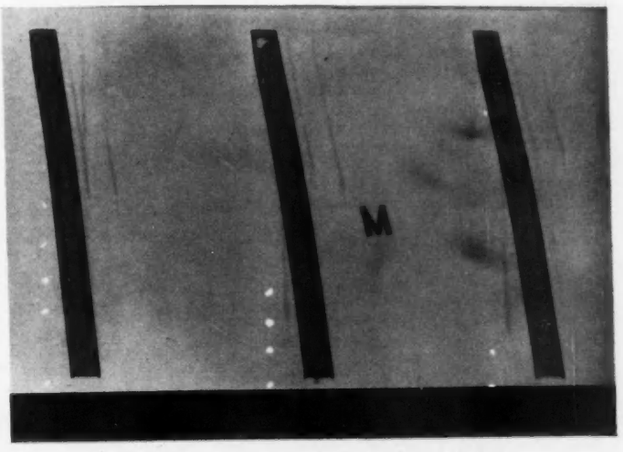


Fig. 4 Unsatisfactory spot welds in a tail structure.

Fig. 5 A complete wing spar was investigated for cracks with this mobile trolley-mounted Pantak 150 kV X-ray source, in which the tube head weighs only 23 lb. 150 radiographs were made in 3¼ hours.

complex, a sectional drawing giving a view normal to the film and covering the area between film and source, may be used to lay out the X-ray optics, thereby obtaining the best position for the source and film. In addition, by superimposing the relevant drawings and viewing against a light, considerable assistance may be obtained in reading radiographs as this allows for the orientation of components by direct reference and gives a similar picture to that obtained radiographically.

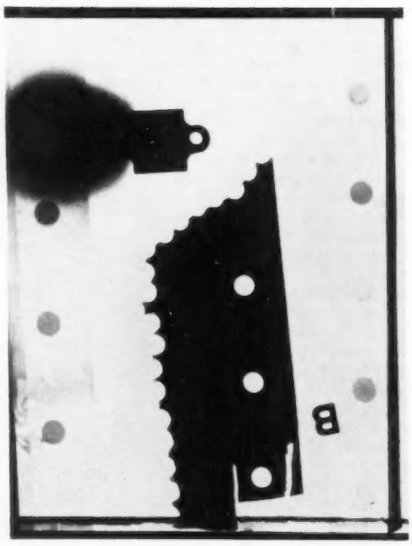
An interesting application of this technique arose in a particular wing in which the spar had been found by visual inspection to contain some small defects. In this case the desired technique of aligning the film at right angles to the plane of the crack and the source was not possible because of internal structure and fittings which would have absorbed too much of the radiation and would have concealed the defects. The films were therefore placed on the wing skin just aft of the spar boom being examined, and the X-ray source was directed upwards at 12 deg. to the horizontal through the leading-edge skin, hot air ducts, bag fuel tanks and plating. The obliquity of the set-up resulted in a distorted image, with elongated rivet holes and hair cracks appearing as a band contained between two lines. The cracks, however, showed up satisfactorily and good correlation was obtained between those revealed by the radiographs and those revealed by dye penetrant after taking down the structure.

In order to examine the complete wing in the minimum possible time, a faster film was used—Ilford G—than that for optimum sensitivity. The X-ray source employed was a Pantak 150 kV head, supplied by Pantak Limited, 72/76 Alpha-street, Slough, Buckinghamshire on a specially designed light-weight manoeuvrable trolley (Fig. 5). An exposure time of 1 minute was employed over the whole span, and the output was stepped up in three stages, from 70 kV to 150 kV, as the depth of the wing increased, the current intensity ranging from 6 to 10 milliamperes. By this means it was found possible to make 150 radiographs, two at a time, within 3¼ hours—a convincing demonstration of the time-saving potentialities of X-radiography, made possible by the flexibility and ease of tube-positioning of the X-ray unit with separate light-weight tube head and high-tension cables.

RADIOGRAPHIC INSPECTION SCHEDULES

The radiographic inspection schedules which Vickers-Armstrongs are intending to prepare will be worked out in consultation with the chief engineer, who can advise on the areas of high stress, where defects would be most likely to arise after many thousands of flying hours, and the possible forms of such defects. Then, having worked out a suitable source-to-film set-up from the aircraft drawings for each area to be checked, a dummy structure will be built up reproducing all the obstacles in the path of the X-ray beam, and simulating typical defects. One method of doing this is to cement a thin cracked structural specimen on to the part in question, as shown in the radiograph reproduced in Fig. 6. A series of radiographs of the dummy structure can then be taken in the radiological laboratory to define the high-tension voltage, current and exposure required for each area. Alternatively, representative test specimens which have already been used for structural tests can be employed as the dummy structure, as shown in Fig. 7, in which there is an extensive fatigue crack. This illustration shows clearly how the rivets farthest from the film lose definition.

For some time to come, however, it seems likely that the large-scale radiographic inspection of aircraft structures will require to be backed up by periodical dismantling and visual inspections to ensure that the X-ray photographs are, in fact, revealing what is present. It has been suggested that it is worth attempting to measure the rate of growth of fatigue cracks in full-scale structural specimens at intervals between the applications of repeated loads, since a similar technique used on operational aircraft might serve as a basis for withdrawing them from service individually instead of, as at present, withdrawing all aircraft at the end of an arbitrary "fatigue life" based on the scatter results of fatigue tests on a number of airframe specimens. Whether this possibility will ever be feasible, either technically or operationally, is a question beyond the scope of present experience.



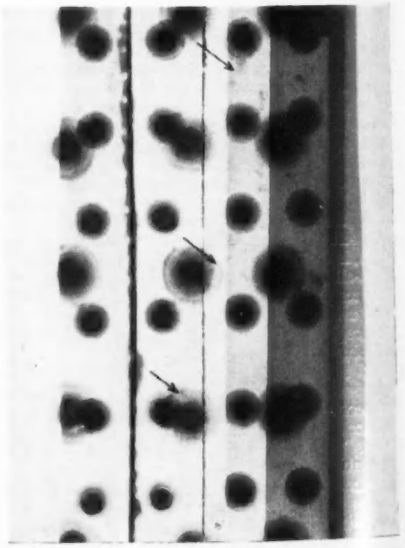


Fig. 6 **Fig. 7**

Figs. 6 and 7 For working out radiographic technique, typical defects can be simulated by cementing on to the area in question a thin cracked structural specimen (Fig. 6); or a structural specimen cracked in fatigue testing can be used as the dummy structure.

(2) AIRCRAFT RADIOGRAPHY ON THE CONTINENT

By E. W. Kowol, M.A.*,

In December 1955, Carl Drenck, Copenhagen, the manufacturers of Fedrex portable industrial X-ray equipment, organised a meeting of aircraft inspectors to discuss the radiography of structures. A report of this meeting, which was held in Copenhagen, is now available.

The object of the meeting was to provide an opportunity for the interchange of information and experience between all those engaged in aircraft radiography in Europe. Several British representatives were present. It was felt that such a meeting was of value, especially as radiography is still a comparatively new method of aircraft inspection and is in many cases at the stage of trial and error experiment.

The importance which is attached to radiography by aircraft operators was illustrated by the fact that those who are actually doing the work occupy important positions on the inspection staff of the airlines concerned. It is generally the object, however, to hand over the actual work to more junior officers once satisfactory radiographic techniques have been worked out. In one case, where this stage has already been reached, however, a keen interest in and fairly close supervision of radiographic work is being maintained by the senior officer concerned.

The equipment being used is in all cases of the single-tank type, i.e., with the X-ray tube and high-tension transformer encased in a tube-head tank. The great advantage of this type of equipment is that only low tension cables are needed and consequently the danger of an explosion of petrol vapour caused by sparking from faulty high-tension cables is eliminated. Maintenance costs are also low, as this type of equipment is made to stand up to site conditions. Equipment on show at the meeting included an economical combination of special interest for aircraft radiography. This was the Fedrex 160

* Inspection Equipment, 19, Broad Court, Drury Lane, London, W.C.2.

Fig. 8 The Fedrex 160 and 120 kV tube heads with a single control unit and set of cables. With this set-up, the thicker sections are covered by the 160 kV head, whereas the 120 kV head can be used in confined spaces such as the interior of the wing.

and 120 kV tube heads with one control unit, Fig. 8, and one set of cables. With this combination, the thicker sections are covered by the 160 kV head, and for work in confined areas, such as wing interiors, the 120 kV tube head can be used. Both tube heads have a fine focal spot.

Either the 120 or the 160 kV Fedrex set is advantageous for aircraft radiography because it forms a nucleus to which extra tube heads can be added as radiographic commitments increase. For instance, the owner of a 160 kV set may subsequently purchase separately a 120 kV tube head for work in confined spaces and on thinner sections where its small size and light weight reduce the time required for positioning. The same control unit and cables are then used for both the 160 and 120 kV tube heads. Another tube head, which functions with the same control unit and cables is the 160 kV with 360 deg. X-ray beam. This tube head could be a great time-saver on fuselages. Films can be placed in a ring right round the outer skin, the tube head positioned centrally and all the films exposed by a single exposure.

European airlines began to use X-rays on structures at the recommendation of the Lockheed and Douglas companies and, up to the present, radiography is mainly confined to aircraft supplied by these manufacturers. The detailed instructions provided both by Douglas and Lockheed have proved invaluable in the early stages but Europe is now catching up with America and a two-way exchange of information has begun. K.L.M. for instance, have worked out a technique for X-ray inspection of nose-section attachment angles of the DC-6. Previously this was thought to be beyond the scope of radiography because of the presence of intervening components. However, it proved to be an economy to dismantle part of the radio rack, the navigator's instrument panel and the steel attachment bolts and then to radiograph, two exposures being made at each side. The saving amounts to some 30 man-hours and details of the technique have been passed on to other Douglas operators.

Improvements of existing techniques and the extension of radiography to parts of the structure previously inspected by more expensive and time consuming methods is a regular process and one by which considerable savings have already been achieved. Representatives of airlines who have just begun radiography expressed confidence that future economies would more than justify both initial outlay on equipment and time spent on experimental work. This was confirmed by those who are already using X-rays as a matter of routine.

RESTRICTIVE PRACTICES BILL

DYNAMIC OR DEADENING INFLUENCE?

By H. J. Novy

We are concerned in this article with the abolition of restrictive practices in British industry. Put more positively and accurately, the British Government are concerned with the promotion of competition in the manufacturing and distribution of goods. In 1948, the Labour Government took a leaf out of the Roosevelt administration's record book, declared war on monopolies and put through Parliament the Monopolies and Restrictive Practices Act. A Commission was appointed to conduct detailed inquiries into matters referred to it by the President of the Board of Trade, to whom it reports. The Act defines a monopoly as " any business or combination of businesses that deals in not less than one-third of the national output of any given product." The Commission's task was to assess what practices are contrary to " the public interest " and certain ministries were given power under the Act to issue a Statutory Order prohibiting such practices.

The implication is that competition is good for the economy, and a necessary ingredient of every dynamic industrial country. The United States is the paragon of all such countries, and it is well provided with anti-trust laws. Therefore, in the eyes of some, the case against monopolies is proven. Once a manufacturing organisation has reached monopoly proportions it has become too vital a concern to be left to conduct its own affairs in its own wisdom.

But is this really the case? If it were, there would be a limit to industrial growth and little point in competition since successful competitors would sooner or later be arraigned before the courts. In days of high taxation, manufacturers can say—and a good many do—What is the point of trying to earn more?, and conclude that jogging along is the best policy. Exposure to the Monopolies Act could produce a similar lethargy, but it would affect mainly the large companies, particularly those which the National Institute of Economic and Social Research estimate account for over a quarter of Britain's manufacturing industry.

Not every large company is a monopoly. Several of the companies listed among the 100 largest have competitors of similar size, such as B.M.C., Ford and Vauxhall. Nor is a monopoly invariably held by a large company, since the demand for the goods it makes can be comparatively small. Yet the fact remains that the Monopolies and Restrictive Practices Act must by definition threaten the growth-conscious manufacturer who has triumphed in the competitive struggle.

FINANCING RESEARCH

Another point worth making at this stage is that scientific progress has become increasingly identified with large research establishments and can almost be calculated as a percentage return on investment. This does not mean that the brilliant engineer who has sufficient faith in himself to start his own company will not produce the answer; only that he is becoming the exception. The monopoly has little incentive to search for new ideas except in so far as these will increase profits; it may shelve an idea which necessitates the extensive replacement of tools and fixtures, or which competes with established products. Yet it is the large firm which is able to bear the heavy overheads of a well-equipped research laboratory. During a war, industry is stimulated by the Government to produce the nation's needs—these may be a jet bomber or an atomic bomb. It is conceivable that during a long period of international peace and disarmament, international cartels would be set up to remove competition from large areas of the world. Yet German industry, more prone than most to monopolies and cartels, has never lagged far behind that of other nations in technological progress or excellence of its products. During the inter-war period Krupp and I.G. Farben were leaders in both respects.

One of the weaknesses of British manufacturing industry is that the medium to small company tends to lack vitality. There is little evidence of a desire to grow, or of much initiative either in the technological field or in the marketing of products, particularly overseas. Yet these companies account for over half the total employment in manufacturing. The tendency is to eliminate competition so far as possible, generally by collective action through trade associations. It was possibly the realisation of this which prompted the Conservative Government to draft their Restrictive Trade Practices Bill, which is now being debated in Parliament, and to appoint in 1954, as chairman of the Monopolies and Restrictive Practices Commission, a member of the Liberal party, Sir David Cairns, Q.C. (who wrote, in 1948, " All restrictive practices as such are inimical to the community "). The Government's reasoning may have been thus: take away the life-belts from the protection-minded and they will begin to swim, or sink Take away their sticks and they will walk unaided or fall. There is no obvious reason why such shock therapy may not work. In fact it is hard to think of any other treatment when so little is left to the profit motive nowadays. Assuming that the lethargy of the medium-sized and small company constitutes the main weakness of the British economy, it follows that only limited gains can be made through investigations by the Monopolies Commission. In future, therefore, the Commission will concern itself mainly with what the President of the Board of Trade calls " single-firm monopoly."

The whole emphasis of the new Act will thus be on collective agreements which are defined as " against the public interest." Practices which are considered to be in restraint of trade will require to be placed on a register which will be open to public inspection. A confidential section will contain agreements relating to legitimate trade secrets (e.g., the use of unpatented inventions, information about mineral deposits, etc.) or to matters which, in the opinion of the Board of Trade, it would not be in the public interest to reveal (e.g., information which may prejudice a company's or an industry's sales overseas). The Registrar of Restrictive Trading Practices, who will be appointed by the Crown and will not be a servant of the Board of Trade, will be responsible for maintaining the register

and for taking proceedings before the Restrictive Practices Court.

The registrar will be a very powerful person with, in some circumstances, the right of entry and search without Court Order. It was over the definition of his constitutional status and duties that the Opposition made their first challenge when the Bill was discussed in Committee. The President of the Board of Trade, Mr. Thorneycroft, pointed out that his department retained a great deal of initiative in the matter of putting forward items for registration and could have the right to influence the order in which cases were heard in certain exceptional cases. He resisted all attempts to make the Registrar responsible to the Board—on the ground that there could be no parallel discussions of matters in a Judicial Court and in Parliament. Parliament's powers to scrutinise the working of the Restrictive Practices legislation when the Bill becomes an Act will therefore be very limited.

IN THE PUBLIC INTEREST

The Judicial Tribunal to be set up will have the status and powers of the High Court. The Bill provides that the Court may sit in three divisions, each consisting of a High Court Judge who will preside, and two lay members " with knowledge of or experience in industry, commerce or public affairs." The decision of the Court will be by a majority of the whole Court or of the members sitting, but the decision of the presiding judge will prevail on a point of law. It will be for the Court to decide what is or is not in the public interest. But the Bill specifies that the Court will find the restrictive practice before them contrary to the public interest unless—and here is the vital clause to which there is so much opposition from industry and commerce—" . . . unless the parties to the agreement discharge the onus which is put upon them by satisfying the Court that the restriction does some good—or prevents some harm—in ways specified in the Bill, and further does not operate to an unreasonable extent to the detriment of persons not parties to the agreement, such as consumers or would-be entrants to the trade, or otherwise to the detriment of members of the public." (Board of Trade Statement, February 15, 1956.)

The Federation of British Industries, the National Union of Manufacturers and the Association of British Chambers of Commerce, who expressed their approval of the object and procedure of the Bill, denounced this in the strongest term: " This is like assuming a man to be guilty of an offence unless he can prove his innocence," and pointed out that parties to an agreement are severely limited in the grounds they can quote for justification. It is evident that industry will be put to a great deal of expense, as well as worry, when it is required to justify a restriction on the seven main grounds listed in the Bill on which such a justification can be pleaded. There is no doubt that the F.B.I. are right in claiming that the grounds are themselves severely restrictive, and that there is a case for placing the onus of proof that a restrictive practice is contrary to public interest squarely on the members of the Court. The Conservative backbenchers want to add an eighth ground on which exemption may be secured: that the removal of the restrictions would do more harm to its operators (or third parties) than it would do good to others. Should this amendment be carried there would be grounds for criticising the Bill for being too vague and for leaving too many loopholes. Already a great deal is being left to the interpretation of the Court, and if more is added one could fairly say that the Bill would do more good to the legal profession than to the British economy.

The collective enforcement of resale price maintenance is banned outright. This means that, when the Bill becomes law, organisations such as the British Motor Trade Association will have to be disbanded. There is likely to be strenuous opposition to this clause, since industry believes that the only practical method to maintain prices at a level which permits reasonable margins of profit is by collective enforcement. The arguments in favour of this method are stated very forcefully in Mr. K. C. Johnson-Davies's recent book: *The Practice of Price Maintenance*.* The author has for over 20 years been the secretary of the British Motor Trade Association and therefore writes as an experienced administrator of a scheme which has worked well, whether maintaining prices or containing them as B.M.T.A. did during six years after the war. Mr. Johnson-Davies considers that collective resale price maintenance as practised by B.M.T.A. is the only workable method to ensure that the list prices of manufacturers and the profit margins of dealers and sub-dealers are maintained at a level adequate to permit efficient distribution and service of motor vehicles. In a statement in the House of Commons last July, the President of the Board of Trade recognised that there was " a powerful body of support, including consumers, in favour of the individual fixing of retail prices while, at the same time, for many of the goods the only effective method of enforcement is the collective arrangement." But at the same time the Board point out that there is considerable criticism of the methods of collective enforcement of resale prices, " especially on account of the private trade courts maintained for the purpose," which include the placing of retailers on a stop list, thus cutting off their supplies from all manufacturers, and the imposition of fines.

PRICE MAINTENANCE

The ban on collective resale price maintenance obviously raises major problems for the engineering industry: manufacturers of most consumer durable goods are affected as well as the manufacturers of a wide range of components and spare parts. The B.M.T.A. have suggested that if the objections are to the methods of enforcement rather than to the collective maintenance of prices, then the correct action would be to amend Section 1B of the Trade Union Act 1876, by virtue of which " any trade association or other organisation, the principal object of which is the enforcement of price maintenance, or other similar practices, is automatically a trade union and therefore prohibited from enforcing its rule or agreements in the Courts." If this were done, industry could enforce collective price maintenance " by the legal process," and then all the objectionable features of the scheme—" secret courts " and their sanctions of stop lists and fines —could be abolished.

The Government's proposal to " make the price run with the goods " thus giving powers to manufacturers to bring proceedings against traders who knowingly infringe resale price conditions (even if there is no contractual relationship), is unlikely to work very satisfactorily. Retailers injured by price cutting on the part of competitors have no redress save through the manufacturer, who may not wish to take action. Only the largest manufacturers could be expected to enforce their prices, and even they may think twice before sueing important customers. Experience in the U.S., where this method is the only one permitted, suggests that it works only very imperfectly. It has doubtless played a part in the rapid extension of exclusive dealerships in the industries concerned (when withdrawal of supplies becomes a more effective weapon) and it may also have been an important influence on the growth of concentration in the industries concerned, particularly the motor and the electrical engineering industries. The problem of resale price maintenance will loom very large indeed if the ban on collective action is maintained.

The last main feature of the Restrictive Trade Practices Bill is the proposal to form a small and more compact Monopolies Commission for dealing mainly with " single-firm " monopolies. This will obviously restrict considerably the future work of the Commission. So far, reports have been published on dental goods, cast iron rainwater goods, electric lamps, insulated electric wires, insulin, and pneumatic tyres. A report on the linoleum industry has been completed but not published and reports are nearing completion on heavy electrical plant, standard metal windows and doors, rubber footwear, industrial and medical gases and tea. Inquiries into electric batteries, steel frames for building and street lighting equipment have been shelved. Of all the 15 reports completed or shelved, eight have been concerned with engineering or metal industries and two with important suppliers to those industries.

It is, therefore, the engineering industry which is likely to be particularly affected by the Restrictive Trade Practices Bill when it becomes law. It is only to be hoped that the Restrictive Practices Courts will be so constituted that in their interpretation of public interest they do not trample on the interests of manufacturing industry, which is the life blood of our economy. They may succeed in fostering in the industries they investigate the drive and vitality needed for competitive success in overseas markets. On the other hand they may add yet another burden to the manufacturer's already heavy load. With the profit motive blunted by taxation, enterprise stifled by the credit squeeze, costs driven upwards by the huge monopolies of labour, transport and fuel, small wonder the young British entrepreneur looks to other countries.

* Iliffe and Sons Ltd., London, 1955 (15*s*.).

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EXPANDED METAL

Possible Application of Technique to Plastics

To demonstrate the versatility of " expanded metal," the Expanded Metal Company, Limited, Burwood House, Caxton street, London, S.W.1, recently staged an exhibition. Since the building industry is still the major user of expanded metal, a large proportion of the exhibits were devoted to its use as structural reinforcement and for non-slip industrial floors. Expanded metal is, however, being increasingly applied in agriculture, in the electrical and radio industries, automobile manufacture, aircraft, mining, for domestic uses and for display and advertising.

Three recent uses draw attention to its possibilities:—the " snowflakes " of expanded aluminium used as Christmas decorations in Regent-street this winter; the expanded metal foundations for the base huts erected by the trans-Antarctic expedition; and the use by British troops in Cyprus of expanded metal shields as protection against stones.

In the Chicago fire of 1871, the greater part of the city was destroyed. This stimulated architects and builders to search for a strong, practical metal base which would afford greater protection for plastered walls and ceilings in case of fire. In 1884, John F. Golding, of Chicago, invented a machine for making metal lath. This machine cut slits in sheets of steel, the slits then being pushed apart until a mesh was created.

Expanded metal demonstrated its value in dramatic fashion during the San Francisco earthquake of 1906. Amid ruin and destruction on a gigantic scale, almost the only structure left standing was a multi-storied building which had been reinforced with expanded metal.

Although there have been improvements in technique and design, Golding's method of cutting slits in a sheet of metal and then pushing them apart to form a mesh is still the basic method of manufacturing expanding metal. To-day there are more than 350 varieties.

So long as reinforcement in building was almost its only function, expanded metal was made exclusively of steel. Nowadays it is made of stainless steel, aluminium, copper, brass and other alloys. There have been occasions when even gold and silver have been expanded. At present, research is going on into the possibility of expanding plastics. Two major results of research since the second World War have been the introduction of flattened expanded metal and of " safe-mesh " expanded metal.

Institu[illegible]f Naval Architects Spring Meeting (*continued from page* 207)

SH[illegible] REPAIRS NEED DOCKS, STEEL AND LABOUR

The first [illegible]ical session in the Spring Meeting of the I[illegible]on of Naval Architects, held in the Weir Hall of the Institution's headquarters in London, followed [illegible]mediately after the Annual General Meeting [illegible]e morning of Tuesday, March 20. The President, Viscount Runciman of Doxford, O.B.E., A.F.C., D.C.L., continued in the chair and invited Mr. H. A. J. Silley to present the first of the nine papers before the Meeting, on "Ship Repairing—Some Aspects of the Industry To-day."

SHIP REPAIRING

Mr. Silley's paper was unusually short—hardly more than 2,000 words—but it covered the present problems of the ship-repairing industry with notable skill and provoked a discussion which fully occupied the remainder of the morning. Ship repairing, he said, had grown rapidly in importance since the beginning of the century and it was estimated that the turn-over of the industry in 1955 was about £70,000,000. As a result of the development of various navigational aids, radar in particular, the main emphasis had now shifted from damage repairs to quick and efficient maintenance. There were four main factors to be considered in providing repair and maintenance services, namely, technical ability, equipment, manpower and materials.

Skilled manpower was a serious problem. Apprentices tended to drift away from the industry after the conclusion of their training, which affected the supply of estimating and managerial staff with repair experience. The slump between the wars led to the emigration of many skilled men and since 1945 there had been a further steady decline. In particular, there was a heavy demand for electricians and welders. Restrictive practices, such as demarcation between trades, were a severe handicap.

Shortage of materials, especially steel, was another. The shipbuilder was able to estimate his steel requirements a long time in advance, but the repairer could not. The modern trend towards greater size of ships also presented new and complex problems. There were now well over 200 tankers in service of more than 24,000 tons deadweight, and many of more than 90 ft. beam. Many dry docks built before the war were unable to receive such ships. There was special difficulty, too, in docking large passenger liners, because their docking draught was only a little less than their normal draught.

The advent of the all-welded ship, usually constructed of large prefabricated sections, had made it desirable to provide similar welding facilities in repair yards. The importance of adequate cranes and ship-to-shop transport had increased as the size of hull and engine parts had grown; and the problem of removing parts from inside the hull was complicated by the increased amount of electric wiring and service piping in the machinery spaces. Incidentally, he added, fabrication in shipbuilding seemed to have accentuated corrosion troubles. The use of high-pressure boilers and of large turbine units had rendered necessary special shops for their maintenance; and radar, and the growing use of electronics, meant the employment of specialist sub-contractors. Disposal of oily sludge and oily water required the provision of large tank-cleaning plants.

DISCUSSION

Sir Lawrence Edwards, O.B.E., who opened the discussion, said that while in peace, ship repairing was a most valuable economic asset, in war it was a vital factor of national defence. It was well to bear in mind that there were more dry docks over 200 ft. long in this country in 1914 than there were in 1939, and there were still more in 1914 than to-day. The most marked change in the job of the ship repairer since pre-war days was the very rapid increase in the size of ships, especially tankers. Without doubt, the biggest bottle-neck in the United Kingdom and elsewhere in ship repairing was the dry-dock capacity. Nothing whatever had been done to the public dry docks of the country for many years, and nothing at all since the war. The present steel position was a reflection on the organising ability of the steel trade. Surely, if the requirements for ship repairing could be met in the war days something could be done about that now. The repair industry, consuming but a fraction of the steel utilised in shipbuilding, was putting back into service (or was holding [illegible] almost as many ships in one week as the shipyards delivered in a year. With regard to labour, [illegible] work only 44 hours out of the 168 hours in a week could hardly be described as making the best use of the time available.

Mr. [illegible] Champness, M.B.E., said that Mr. Silley's figure of £70 millions turnover became more significant when compared with the £10½ millions in 1907. Even allowing for the lower value of money, the growth factor was very considerable; and that, allied with the fact that the number of dry docks in this country was even less than before, gave some indication of the pressure on the dry docks to-day. It was true, however, that the industry had been prevented from going into top gear; a five-day week and a total closure for two consecutive weeks per year, and bans on overtime were sheer nonsense in a servicing industry. Continuity always was and always would be the lot of a servicing industry; continuity by sufficient men working the normal number of working hours per week only, but with proper rotations of shifts.

MAINLY MAINTENANCE WORK

Lieut.-Col. Eustace Smith observed that it was stated in the paper that the main emphasis had now shifted from damage repairs to quick and efficient maintenance, but he maintained that the volume of steelwork that was still being carried out by the ship repairing industry was as great as, if not greater than, it was when there were so many damage jobs. The problem of taxation and the obsolescence of docks could not be emphasised too much. A point which had not been emphasised concerned the provision of quay space and wharves; it was almost as vital to have quays as to have docks.

Mr. David Skae agreed with the author that the ship-repairing industry was an efficient machine which could not get into top gear. It was plagued by demarcation, by completely outworn practices which should be swept away. Many of the older docks in this country were obsolete, and in many cases the building of new, bigger and deeper drydocks was precluded by the cost, generally between £1 and £2 million. The repair of welded ships had loomed large in the eyes of ship repairers in recent years. Was it right, when studying the repair of damage on the side or the bottom of a welded ship, to consider existing butts and seams? Occasionally he had been asked by owners to cut along the lines of existing welds.

Mr. G. A. Bassett found it "rather surprising" that every main port in Europe had one large dock capable of taking the largest oiler and a big passenger ship as well; or, if such a dock were not there, provision was being made to provide one. The State would be financing it, and the State itself was financed by American aid. Those docks, when provided, were fully equipped. At the start of the war many docks in this country were merely holes in the ground, and in many cases the roads leading to them were not good. At Continental ports, where war devastation was general, they had not only rebuilt the yards and provided good docks, but also very fine access roads, good cranes, and extraordinarily good engine shops. At Naples, one of the biggest docks in Europe had been completed recently; it was double-ended and divided into three sections.

Captain J. P. Thomson, O.B.E., thought that the success which had been achieved by the repairers was due to very close co-operation with the master of a ship, with the owners, and with the superintendent; they kept in close touch with a ship between dry dockings, which occurred probably once a year, and they were able to see the results of their labours.

Professor E. V. Telfer asked what the ship-repairing industry was doing about research in ship repairing; what were they really doing to help the shipowners to obtain better ships and to profit by the mistakes that shipbuilders occasionally inflicted on them? Was there any practical reason why side shoring for the modern ship should continue? If repairers wanted a first subject for research, would they institute it into dry docking, from the point of view of having adequate support on the centre blocks, without having too many bilge blocks to put in, which would delay the carrying out of the repairs? In connection with education, he hoped that Mr. Silley would say what steps were being taken in the ship repairing industry to produce better-educated people. If something was done in that direction, ship repairing would become a real profession.

Major J. Caldwell referred to the author's remark that radar and electronics had meant, in many cases, the employment of specialist sub-contractors and the provision for them of storage space and other facilities. He thought that those remarks could well apply also to other specialists, including the welding contractor and sub-contractor.

Mr. R. A. Crockett said that it was the training of the workpeople and the selection of the charge-hands which determined whether that job was done quickly and efficiently. By giving the workman a feeling of responsibility, they gave him also the desire to get a job done efficiently.

Mr. G. M. Boyd thought that to go on making bigger and deeper holes in the ground for bigger and bigger ships was an uneconomical way of going about things. The suggestion of having sectional docks which could be used for two or three ships at once had been put into operation by Mussolini, and he did not see why that should not be done here.

SPEED OR COST

The President said that he wished to ask a question or two from the point of view of the man who, after all, had to do the paying. It had been suggested that, on the whole, the shipowner could get ordinary repair work done slightly cheaper in this country, but the work took longer; it cost slightly more on the Continent, but did not take so long. That had been his experience more than once. It would not be right to say that either of those would necessarily be better than the other. Sometimes there was a boom and a ship became worth, as a tramp, £500 to £5,000 a day, and the owner was willing to pay more to get his ship repaired quickly; whereas, when earnings came down a lot, he looked at the problem rather differently. He did not want to venture deeply into the difficult field concerning labour. The labourer's problem was not unlike that of the shipowner; there was no fear of unemployment, and he had the feeling that leisure was more important than money, beyond a certain level. It was unfair to say that either was a feeling that he ought not to have.

The matter of docks was not so much their number as the relation of the number of docks to the number of ships; and the docks had to be bigger when the ships were bigger. It seemed reasonable to support the plea that if a shipowner was given an investment allowance to build a ship, the repairer should have an allowance for building something which must be there if the ship was to be used; but everybody was clamouring for money for capital improvements. If they were all undertaken at once, the nation would starve while they were being done. Was one of the difficulties the physical location of a number of shipyards and repair places?

Mr. Silley, replying to the discussion, said that he did not mean to infer that British yards were not now doing the big jobs; but he thought, as Sir Lawrence Edwards had said, that they used only a very small proportion of the steel output to maintain the industry in a state to keep the ships moving. The steel position was becoming a source of very great anxiety. His own firm, at Falmouth, had been obliged to turn down a large number of ships over the past few months, partly due to the steel shortage and partly to the dry dock position. With regard to labour, perhaps the greatest bugbear was demarcation. To those who are dealing directly with trade-union officials, shop stewards and others, it was heart-breaking to get such negative results from their approaches to problems which could be solved by the application of a little common sense and intelligence.

Much had been heard about the greater speed of ship repairs on the Continent as compared with this country, but the claims were not always borne out. He was very sure that more and larger dry docks were needed. During the last war and immediately following it, they had been discouraged from spending money on maintenance and extensions to the detriment of the ship repairing establishments.

Whether a floating dock was as efficient as a graving dock, for the purpose of dry-docking and repairing ships, was a matter of opinion. There were factors which controlled the decision in most quarters. One of them, of course, was to get the necessary water. For example, he did not think it would be possible to operate a floating dock anywhere in the Port of London, certainly not one of the size that had been mentioned as an alternative to the big graving dock.

In ship repairing a quick turn-round was the essence of the contract so far as the shipowner was concerned. Some 20 or 30 years ago it was not uncommon for a ship to lay up for a period equal to that of a complete voyage. Nowadays, the owners ran them like trains; they never thought of arranging a lay-up period for a large passenger ship, and the work had to be done when the ship was in port for discharging passengers and cargo and re-loading, and had to be progressive from voyage to voyage. If owners complained that the work was costing more, much of the remedy was in their own hands.

The industry was training its people, and selecting them. In his own firm, for some years, they had encouraged young men to train and had placed them with other firms for periods to gain experience. He agreed entirely on the desirability of ship repair personnel being trained in shipyards; that was what they endeavoured to arrange for the young men whom they selected.

To be continued

BRITISH INDUSTRIES FAIR

ELECTRICAL EXHIBITS AT OLYMPIA

Concluded from page 311

AIR-BREAK SWITCHGEAR

The British Thomson-Houston Company, Limited, Rugby, were showing a wide range of the equipment they manufacture, including switchgear, motors and lamps, as well as germanium and silicon power rectifiers and industrial electronic and marine radar apparatus.

Among the switchgear which was on view mention may be made of the new 3·3 kV air-break equipment, which is illustrated in Fig. 5. This has been tested for a short-circuit rating of 250 MVA, the standard current ratings being 800, 1,200, 1,600 and 2,400 amperes. The contacts of the circuit-breaker are of the high-pressure butt pattern and are silver-faced. The main contact assembly is identical for all current ratings, thus enabling a common arc chute to be employed. Additional contact fingers, which open before the main contacts, are fitted outside the arc chute in the case of the two larger units. The contacts are designed with a " heel and toe " action so that current carrying and arcing duties are effected by the one structure. The arc is transferred from the contact fingers to horn, thereby reducing the burning. The chutes and horns confine and cool the arc, the former being hinged to facilitate contact inspection. Insulation barriers are fitted between poles and between the outer poles and earth.

The breaker is closed by a solenoid mechanism and opened by springs. When the breaker opens, the moving contacts are brought to rest in dashpots, the air in which is thus compressed and then directed across the break. The plugging contacts are of the dumb-bell pattern and are silver-plated. The self-aligning plugs are trapped in the breaker bushings and incorporate internal springs so that the segments make high-pressure line contact with the sockets. The lower set of plugs, which engage with the busbar sockets, form part of a three-positions selection switch which places the equipment " on bars " or isolates or earths it. This switch is operated by the removable handle shown in the illustration so that isolation or earthing can be effected without withdrawing the brush.

MODERN POWER EQUIPMENT

The stand of the General Electric Company, Limited, Kingsway, London, W.C.2, at Olympia was divided into two sections. One of these was being used to demonstrate some examples of modern power equipment, including a complete low-pressure assembly of a 60 MW steam turbine, a 200 h.p. traction motor similar to those supplied to the British Transport Commission for the Southend electrification scheme, and a new automatic flameproof gate-end panel for controlling motors at the coal face. The second section of the stand was devoted to domestic equipment and household appliances.

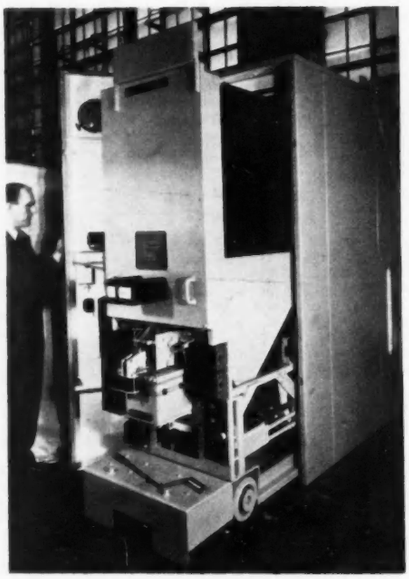


Fig. 10 250 MVA 3·3 kV air-break truck-type switchgear: British Thomson-Houston Co. Ltd.

FLAMEPROOF GATE-END PANEL

The G.E.C. automatic flameproof gate-end panel is shown in Fig. 11. It is designed for the control of squirrel-cage motors at voltages from 400 to 650 volts with full-load currents up to 80 amperes. In design it complies with the relevant specification of the National Coal Board.

As will be seen, the welded sheet-steel enclosing case is mounted on skids and is divided horizontally into two compartments. The top compartment houses 300 ampere busbars and a triple-pole reversing isolator. This isolator, which is of the contactor type and is fitted with series blow-outs and arc chutes, is designed to break 650 amperes at 650 volts with a power factor of 0·2 to 0·3. An auxiliary contact which is connected in series with the contactor operating coil is arranged to open before the main contacts. The operating lever, which is brought out to the front of the unit, carries a catch which engages with a gate on the front cover to prevent the isolator from being moved from the " forward " to the " reverse " position without a pause. A shrouded captive screw is provided to lock the isolator in the " off " position.

The lower compartment houses a withdrawable chassis on which the triple-pole main contactor, twin over-current relays, the core-balance and voltage transformers and the protective relays and fuses are mounted. The chassis also carries a combined test and reset switch, a local control switch and a sequence selector switch with an emergency stop button.

On the top of the chassis are mounted main and auxiliary isolating contacts, which engage with spring-loaded contacts on the underside of the horizontal partition when the chassis is pushed into the case. These contacts complete the connections from the equipment on the chassis to the isolator and thence to the incoming supply and also those to the outgoing cable through a plug and socket on the outside of the bottom compartment.

GEAR-DRIVEN ALTERNATOR

Bruce Peebles and Company, Limited, Edinburgh 5, were exhibiting examples of the plant they manufacture for the generation, transformation and conversion of electrical energy, as well as a range of motors for a variety of applications with outputs up to 2,050 h.p.

As regards generating plant, mention may be made of the 1,000kW 11kV alternator which is illustrated in Fig. 13. This machine was shown to illustrate the company's activities in the manufacture of medium output generators for coupling through gearing to steam or gas turbines. The alternator illustrated is provided with self-contained air filters and main and pilot exciters, which are mounted in one frame.

Fig. 12 shows part of a limb of a 120 MVA 132/275 kV three-phase auto-transformer which was being exhibited in such a way as to enable the core cooling ducts, the tertiary and tapping windings and the series winding between the 132 kV and 275 kV terminals to be inspected. This is an unusual, if not unique exhibit, and it is not surprising that great interest was taken in it.

EXTRA-HIGH-TENSION CIRCUIT-BREAKER

Extra-high-voltage switchgear was the main theme of the display on the stand of A. Reyrolle and Company, Limited, Hebburn, Co. Durham. It comprised examples of both air-blast and small-oil-volume circuit-breakers used in this range of transmission voltages.

The main unit on show was a single-phase unit of a 7,500 MVA 275kV air-blast circuit-breaker complete with its local air receiver. This breaker, which is illustrated in Fig. 14, consists

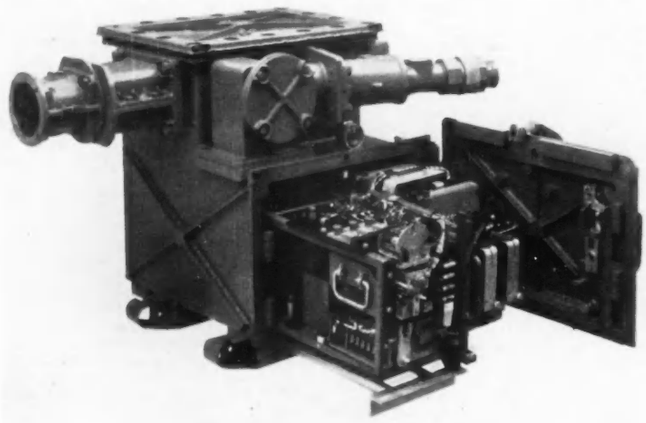


Fig. 11 Automatic flameproof gate-end panel: General Electric Co. Ltd.

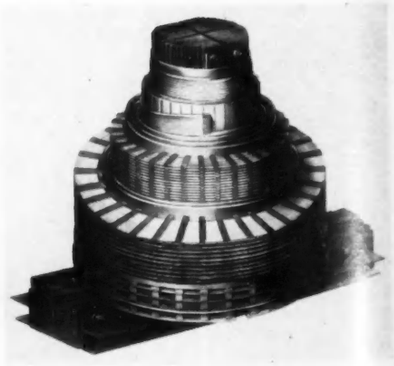


Fig. 12 Limb of 120 MVA 132/275 kV auto-transformer: Bruce Peebles and Co. Ltd.

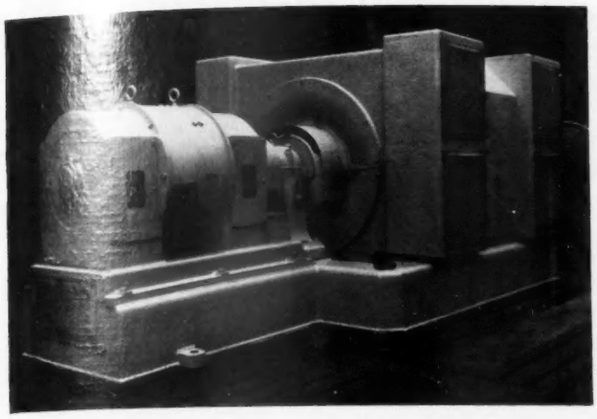


Fig. 13 1,000 kW gear-driven alternator: Bruce Peebles and Co. Ltd.

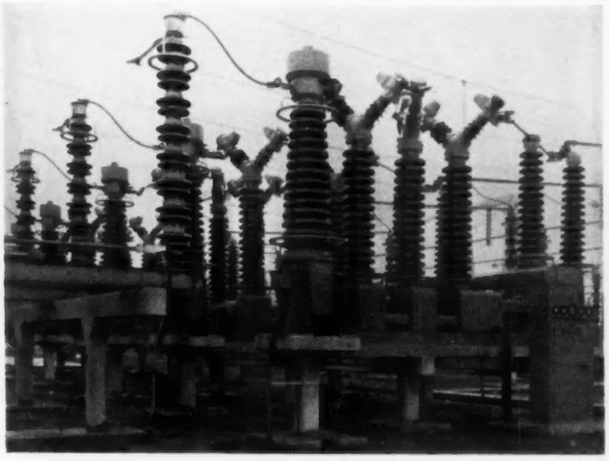


Fig. 14 7,500 MVA 275 kV air-blast circuit-breaker: A Reyrolle & Co. Ltd.

of six air-blast turbulators connected in series with an Isomaker, which provides the necessary clearance across the circuit-breaker in the open position. The circuit-breaker heads containing the turbulators are mounted in pairs on three porcelain columns, and the Isomaker moving arm and its other fixed contact (one of its fixed contacts being integral with the terminal of one of the heads) are supported on similar porcelains. On opening, the arcs are extinguished in the six turbulator heads and immediately after clearance the Isomaker is opened. The moving contacts in the turbulator heads then return to their closed position in readiness for the next closing operation of the circuit-breaker, which is done by means of the Isomaker. A sectioned turbulator head was included in the display to demonstrate the action of the moving contacts and to indicate the principle of arc-extinction.

SMALL OIL-VOLUME UNIT

Alongside the circuit-breaker there were two 300 kV post-type current transformers, one of which was complete, but the other was displayed without its porcelain insulator and casing to show the internal construction of the primary and core. The main insulation consists of oil-impregnated paper, the whole of the housing being filled with oil, and special precautions are taken to ensure that the paper is kept free from moisture.

The other extra-high-voltage circuit-breaker which was displayed was a completely sectioned single-phase unit of a 132 kV 2,500 MVA small-oil-volume circuit-breaker. It is composed of three portions, namely a supporting compartment, a circuit-breaking compartment, and a metal top-cap with a gas vent. The supporting compartment includes an oil-filled metal base chamber and a porcelain insulator, within which the operating links for the moving contact are contained. The circuit-breaking compartment includes upper and lower fixed contacts, through the latter of which the moving contact stem slides, and all of these are contained in a cylindrical Bakelised paper tank, surrounded in turn by a porcelain insulator. The oil in the Bakelised paper tank, used as the arc-extinguishing medium, is entirely separate from the insulating oil, which fills the supporting compartment below and the annular space between the tank wall and the upper porcelain shroud. The metal top-cap, from which the upper fixed contact with its turbulator arc-control device is suspended, is fitted with a silica-gel breather and oil level indicators.

EXHIBITS AT CASTLE BROMWICH

The Castle Bromwich, Birmingham, section of the British Industries Fair, which will in future be the only one to continue in operation, has for some considerable time past housed four main groups of exhibits; hardware, building, electrical and engineering. The equipment on show this year, as on previous occasions, included much of a domestic nature, or otherwise not of particular engineering interest, and in the engineering section there were numerous products which have already been dealt with in our columns.

We give below short accounts of some of the other exhibits of engineering interest.

WINDOW GLAZING

Among the many different forms of window and roof glazing shown by Henry Hope and Sons, Limited, Smethwick, Birmingham, were two different types of double glazing, a development which has long been considered a necessity in cold climates, and is of increasing importance in this country as a result of the need for fuel economy. One method of carrying out this type of glazing is by means of a special glazing clip and [illegible] putty, which is suitable for use with "Plyglas" or "Insulight" up to $\frac{7}{16}$ in. thick. This method is applicable to all types of Hope's standard domestic windows.

For double glazing more than $\frac{7}{16}$ in. thick the method exhibited employs extruded aluminium [illegible]ts and non-setting putty. These inserts, which are made in bar form, are partly filled with non-setting putty and applied on all four sides of each glass panel until the mitres meet.

PACKAGED VERTICAL BOILER

What is claimed to be the only vertical steam-raising packaged boiler available in this country was exhibited by Spanner Boilers, Limited, 258 Brixton-hill, London, S.W.2. This boiler has been designed primarily for installation in Diesel-electric locomotives for train-heating duties, but it is now available in various sizes, with outputs ranging from 250 lb. to 2,000 lb. of steam per hour.

The boiler incorporates the company's "Swirlyflo" fire tubes, which have walls formed into helical flutes. They are made from hot-rolled seamless steel tubes and roller-expanded into the tube plates. Stay tubes of the same material are welded into the tube plates. The form of the fire tube is such that the hot gases are spun against the tube walls, and the rate of heat transfer is raised to such an extent that boilers can be made considerably shorter for the same duty than those employing conventional straight tubes.

Pump, oil burner and all necessary controls and instruments are fitted to form an integral part of the complete boiler unit, which requires only a flat level floor of sufficient strength to carry its dead weight, and a flue connection to atmosphere. The vertical boiler has a small water content, which reduces its gross weight; this, with the small space requirements, make it particularly suitable for use in restricted and difficult conditions, such as the train-heating service for which it was originally designed, or on ship. The basic design is applied to the horizontal form as well as to the vertical, and boilers of this type are made in packaged form, for direct firing, for waste-heat recovery, and for use with Diesel engine exhaust gases.

PORTABLE HYDRAULIC PLATFORM

Two models of the Simon hydraulic platform were exhibited on the stand of Simon Engineering (Midlands), Limited, Queens Cross, Dudley, Worcestershire, the standard 40 ft. model, which was introduced 12 months ago and a new, smaller version, the 38 ft. model. Both machines are basically the same, consisting of a working platform carried on the end of a jointed and swivelling boom mounted on a road vehicle chassis. Movements of the arm are controlled from the platform; there is a duplicate set of controls at turntable level. The larger, or standard model which has already been described in ENGINEERING has a maximum working height of 40 ft., and maximum radius of 26 ft. It is mounted on a 5 ton commercial vehicle chassis, and is powered by a petrol engine mounted on the turntable.

Fig. 1 New and smaller model of hydraulic platform for mounting on a light vehicle: Simon Engineering (Midlands), Ltd.

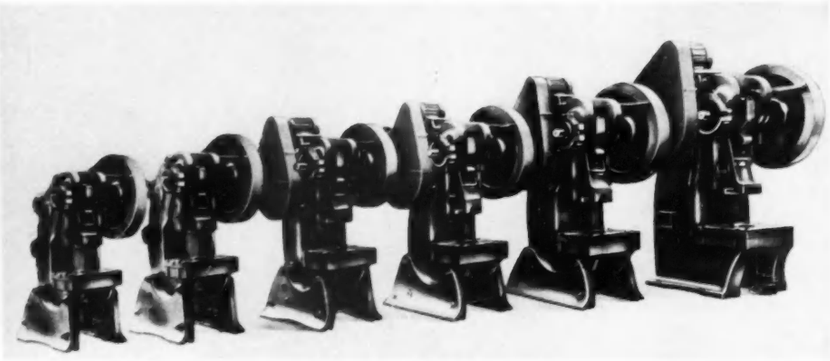


Fig. 2 Range of power presses: Hordern, Mason and Edwards, Ltd.

The smaller model, which is illustrated in Fig. 1, has a platform 3 ft. wide by 2 ft. 1 in. long, with safety rails 4 ft. high and 8 in. toe boards. It has a safe working load of 500 lb. Four pedals are used to control the movements of the boom, and a hand-lever controls the rotation, which can be through 360 deg. continuously in either direction. The speed of rotation is 2¼ minutes per revolution, and the platform elevates at 25 ft. per min.

Normal mounting for the machine is on the chassis of any standard 3 ton long-wheelbase forward-control commercial vehicle, power for hydraulic pump operation being supplied through a power take-off from the vehicle engine. Alternatively the machine can be mounted on a trailer suitable for towing behind a tractor, which provides power from its take-off shaft, or on an electric truck. When trailer mounted the machine can be powered by a 3 h.p. petrol or Diesel engine if required.

Outriggers are fitted, whatever type of vehicle is chosen, and the machine has all the safety features of the larger model. These include self-locking of the platform to prevent swinging if the vehicle is standing on a gradient, and automatic cut-out should the platform descend on any solid object, or pass beyond set limits. If the pump should stop or fail, the platform stays in position until lowered by the operator, and descent is limited to a safe speed, even if a hydraulic line should break.

AUTOMATIC TARING AND FILLING OF DRUMS WITH LIQUID

Among the weighing and testing machines exhibited at Castle Bromwich by W. and T. Avery, Limited, Soho Foundry, Birmingham, 40, was a scale for filling drums with liquid automatically, the weight of each drum being tared off by the scale also automatically. Control of the scale on this machine, which is illustrated in Fig. 3, is effected through electrical contacts which are operated by the dial-type weight-indicating mechanism, and electronic amplifiers and relays which control the filling valves.

In operation, the electricity supply is switched on, and an empty drum is placed on the scale platform as soon as a green light at the control point is illuminated. The weight of the drum then causes the scale pointer to leave the zero position, and one of two contacts will be closed, according to the direction of movement of the pointer. A taring motor next operates automatically in the appropriate direction to bring the pointer back to zero, when the circuit is broken and the motor is stopped. Subsequently, a relay cuts out the taring circuit and energises two solenoids to lift the "liquid free" valve to its fully open position. Liquid then flows into the drum at maximum speed until the weight indicating pointer reaches a point on the chart just short of the pre-set correct weight. At this point a second contact is made, and one valve solenoid is de-energised; this reduces the valve opening and cuts the feed to a dribble. The reduced feed continues until the correct weight is indicated by the pointer, when the final contact closes, and the flow of liquid is stopped completely.

The points at which the main and dribble feeds are cut off can be set as required, to fill drums of different capacities. Possible variations in design allow for the supply of liquid to be by gravity or pressure, for the dribble feed to be omitted, for the feed valves to be operated by compressed air instead of solenoids, and for filling free-flowing powders. Safety devices can be included in the circuit and the scale graduated in any size from 10 lb. upwards.

THREAD COMPARATOR

A new external thread comparator was included in the exhibits of the Coventry Gauge and Tool Company, Limited, Coventry. Designed for rapid gauging to close limits, the comparator consists of two threaded gauging segments, so mounted in a small body that they can be separated by internal spring pressure and expanded to the size of the thread to be measured. In this expanded position they engage with the thread of the component being checked, and show, by means of a dial indicator, with graduations of 0·0001 in., the relationship of the thread being gauged with that of a master ring to which the comparator has been set. The comparator, which weighs only 8 oz., is held in the hand, and by thumb pressure the two gauging segments are brought sufficiently close together to enable them to be inserted in the thread under test. The pressure is then released gently and the segments engage the thread, simultaneously actuating the dial indicator, the zero position of which is adjustable to the most convenient reading position.

As the components being checked are not screwed on and off the comparator, wear is very small, and as gauging takes place under the constant pressure of a spring, errors due to "feel" are eliminated. Segments can be interchanged quickly to suit various diameters of threaded hole. The normal range of the comparator is from ⅜ in. to 1 in. diameter, but special segments are available for fine threads down to ¼ in. diameter. Models are produced for either right-hand or left-hand threads, and there is a full range of Metric sizes.

RANGE OF POWER PRESSES

Among the power presses shown by Hordern, Mason and Edwards, Limited, Woodlands Farm-road, Tyburn, Birmingham, 24, was a new range of seven presses, the capacities being from 20 to 100 tons. The presses, which are illustrated in Fig. 2, are of the open-fronted type, are built to a standardised specification and design. They are all inclinable except the 100 ton machine.

The press frame is of rigid construction, no tie-bars being necessary, and the crankshaft is of alloy steel. The clutch, which can be serviced without removing the flywheel, incorporates a non-repeat mechanism which is so designed as to make repeat strokes impossible as long as the press is set for single-stroke operation. Ratchet adjustment to the slide, with simple, positive locking, and a massive T-slotted bolster plate with a removable bed ring, facilitate tool-setting.

Additional equipment includes pneumatic balancing of the slide, which is standard on the 75 and 100 ton machines, and optional on the 40 and 55 ton models. For the 20 ton press there is available a newly-designed roll-feed attachment, which is a self-contained unit integral with a bed-plate interchangeable with the detachable bolster plate. Double or single roll feeds can be supplied, to take stock up to 6 in. or 9 in. wide.

CLEAN FILLING OF GREASE GUNS

The "Nubrex" cartridge grease gun, shown by Ch. J. Neuman, Limited, South Croydon, Surrey, is filled from a cartridge, which gives 300 "shots" of grease. To fill the gun the pressure is released, and the head unscrewed. The flat lid at one end of the cartridge is then removed and the cartridge is inserted. It only remains to remove the clip-on lid at the other end of the cartridge, and screw the head of the gun into position. The gun can then be used in the normal manner.

The same manufacturers also supply equipment which fills grease guns from kegs or containers. This consists of a head which can be clamped in position on the top of a keg of grease by means of four wing nuts, the clamping being adjustable for different sizes of keg. The gun is fitted with a special self-opening and self-sealing nipple, which is pushed by hand into position on the filler valve on the filling unit head, no tools being needed. One stroke of the hand pump on the filling unit suffices to fill the gun, which can then be withdrawn and is ready for use. The filling head is provided with a length of hose terminating in a hand-lever controlled gun, and the unit can therefore be used as a self-contained greaser when required.

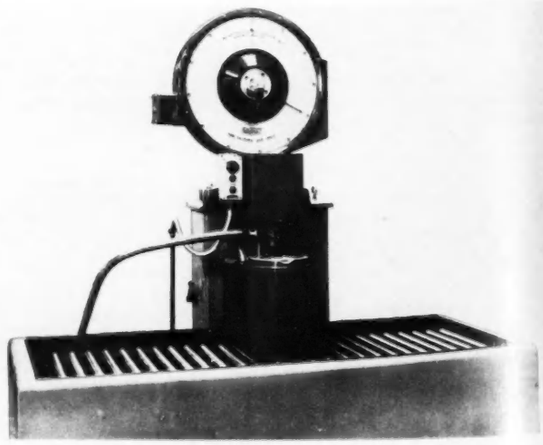


Fig. 3 Weighing scale for filling drums with liquid automatically: W. and T. Avery, Ltd.

Equipment for batch production of parts for small centrifugal pumps occupies part of the Timperley works.

Another section of the works is equipped for servicing and repair of pumps and motors.

PRODUCTION AND OVERHAUL OF SMALL CENTRIFUGAL PUMPS

NEW PLANT FOR HARLAND ENGINEERING CO., LTD.

Until recently the Alloa works of the Harland Engineering Company, Limited, have been responsible for the whole of the large range of products made by the company, a repair shop at Manchester dealing with servicing and overhaul of centrifugal pumps.

To relieve the pressure on the works at Alloa, and to provide improved facilities for the manufacture of small and medium centrifugal pumps, for their repair and overhaul, and for the production of spare parts, the company have taken over existing premises at Timperley, Cheshire, and equipped them as a light engineering works and spares and service shop. The new works were officially opened on April 6, 1956, by Mr. C. A. Atchley, O.B.E., a director of the company who was one of the original founders of the business in 1903.

PUMP PRODUCTION

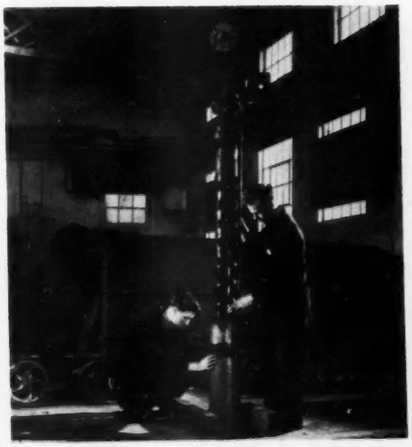
The light engineering section of the Timperley works lies immediately behind the general offices, and consists of a machine shop, stores and assembly shop. Particular attention has been paid to working conditions, the buildings being decorated in cream and green, with blue-grey machine tools and red lifting tackle. Lighting is principally by north roof glazing; heating is from suspended hot-water radiant panels. The machine tools are arranged in rows, with very wide spacing, giving ample room for the transport of components by means of fork-lift trucks and pallets. Where the weight of an individual component requires it, each machine is equipped with its own hand-operated jib crane.

Castings are stored and weathered in an open-air yard adjoining the machine shop, and from here they pass in batches through a preparatory bay where they are shot-blasted, dressed and pre-painted. This bay also houses the steel stock, and batches of steel for machining are made up here ready to accompany the castings to the machine shop. In the machining section the production flow is in three lines. Volutes or suction covers travel down one line of machines to the inspection bench. Impellers are machined in the second line, passing through an impeller-filing and dynamic balancing area to the inspection bench. Shafts pass along the third line for turning, grinding and keyseating operations to the inspection point. Provision is also made in the layout of the machine shop for the production of small parts such as impeller-fixing screws. The machine tool equipment of the shop is in accordance with modern production engineering practice, the tools being of standard types, including a Forst keyseater and a Churchill-Redman copying lathe.

Finished components pass to a stores area, which separates the machine and assembly shops. From this point the parts are issued, together with the necessary purchased items such as screws, nuts and bolts, in batches ready for assembly. Roller conveyors are used for moving assembled pumps to a pressure-test point and on to a turntable, where they are spray-painted. A 2 ft. gauge tramway leads from the assembly shop to the spares and service shop, where there are facilities for testing both new and rebuilt pumps.

SERVICING

The spares and service shop, which is self-contained, replaces the old Manchester repair shop, and offices are provided here for the plant inspection service and erection staff of the company, as well as for the staff concerned with the running of the Timperley shop itself. The shop is equipped with its own machine tools for the production of spares, and its own stores. There are four overhead electric travelling cranes, the maximum lift available being 20 tons. As the amount and type of service work which will be in the shop at any particular time cannot be forecast accurately, and the loading of the machines cannot as a consequence be planned, the machine tools are all of simple basic types, chosen for versatility rather than high production rates.



Testing department for new and repaired pumps.

Each pump arriving in the shop for repair or overhaul is stripped and examined. A report is then made on it, and a programme of work arranged accordingly, new components being drawn from the spares stores or machined as required. All the necessary patterns are kept in stock, and can be issued to local iron and non-ferrous foundries for the production of the necessary castings. There are two areas in the shop for dealing with pumps, one for servicing and repair of electric motors, and another for motor re-winding.

After repair a pump passes to the test bay, where it meets finished pumps from the light engineering shop. The test equipment is designed to give flow measurements to British Standard Specifications from 10 to 1,600 gallons per minute, and pressure tests to the same standards up to 1,000 ft. head of water. Electrically it is suitable for starting and running three-phase motors from the 50 cycle mains up to individual ratings of 150 h.p.

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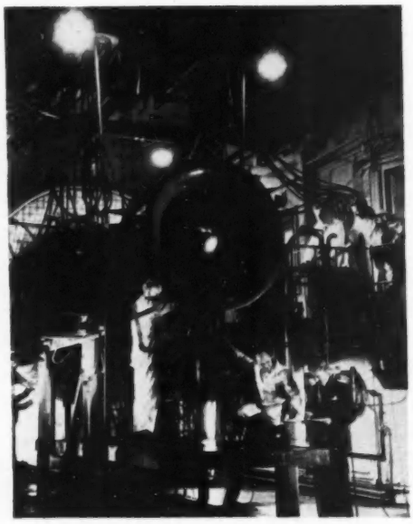
RAILWAY DIESEL ENGINES

Repair Shop at Derby

As a result of the increase in the use of Diesel engines on British Railways, a workshop has been made at Derby to cater for their repair and maintenance. The buildings were formerly used for the repair of locomotive tender tanks and have been completely re-equipped. The accommodation has been based on an anticipated output of 30 engines per week. Engines received at the plant are first passed through a high-pressure spray washer and then the sub-assemblies are removed from them. The separate parts pass back through a second section of the washer and the sub-assemblies are stripped.

The details are then cleaned in three steam-heated boshes and are removed by overhead runways to the test and inspection sections. Details are examined for fractures by the use of ultraviolet ray apparatus and the crankshafts and connecting rods are checked with a magnetic crack detector; all dimensions are checked and those parts requiring repair are passed to another section. Before leaving the shop the engines are tested on Heenan and Froude hydraulic dynamometers.



Lighting for the de Havilland Gyron test-bed is provided by Holophane prismatic flameproof fittings in anti-vibration lampholders.

LIGHTING FOR AN ENGINE TEST HOUSE

The Gyron Test-bed

The accompanying illustration shows the lighting for the de Havilland Engine Company Limited's Gyron turbo-jet test-bed at their Leavesden works. The whole of the lighting for the test-house was supplied by Holophane Limited, Elverton-street, London, S.W.1, and was planned by them in co-operation with the de Havilland company. The choice of fittings was determined by two main considerations—the stringent safety precautions for fire control, and the ability to withstand vibration.

In the main test-bed area which is illustrated here, flameproof pendant fittings with 300 watt G.L.S. tungsten filament lamps and anti-vibratory lampholders were installed in the ceiling to provide approximately 17-20 lumens per square foot. These units are die-cast in silicon-aluminium alloy, with an internal prismatic reflector and a specially-treated prismatic lens, tested to a pressure of 150 lb. per square inch sealed between ring castings.

The control room, a long narrow area with pressure gauges and electric instruments on one side, and a battery of manometers on the opposite wall, is lighted by three and two-light "In-Bilt" Controlens fittings, which are recessed into the lay lights of the building. Maximum efficiency was obtained by using 200 w. G.L.S. lamps in reflector assemblies offset over concentrating lens plates to project the main beams of light immediately forward on to the vertical surfaces to be illuminated. Alternative units were arranged to direct their distribution on either side of the control room. An illumination of 20 lumens per square foot with good uniformity was provided over both vertical surfaces of the control room.

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HIGH-DENSITY POLYTHENE

A high-density stiff polythene, Alkathene HD, will be made available for trial purposes during 1956 by Imperial Chemical Industries Limited, Millbank, London, S.W.1. Alkathene HD can be processed in the same way as the standard low-density Alkathene 20. It is expected to be particularly suitable for mouldings, with improved stiffness and finish. Its electrical properties are equal to those of standard Alkathene 20, and it offers possibilities of thinner cable insulation and a tougher sheath capable of withstanding higher service temperatures.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Discussion on "Water Heating." Central London Branch. St. Ermins Hotel, Caxton-street, S.W.1. Mon., May 14, 7 p.m.
BOURNEMOUTH
Annual General Meeting. Bournemouth Branch. Grand Hotel, Firvale-road, Bournemouth. Tues., May 15, 7.15 p.m.
CREWE
Annual General Meeting. Stoke and Crewe Branch. Royal Hotel, Crewe. Fri., May 18, 7.30 p.m.
MAIDSTONE
Annual General Meeting. Kent Branch. Royal Star Hotel, Maidstone. Sat., May 19, 7.30 p.m.
PORTSMOUTH
"Salesmanship," by R. S. Farr. Portsmouth Branch. 598 Commercial-road, Mile End, Portsmouth. Tues., May 15, 7.30 p.m.
SOUTHAMPTON
Open Meeting. Southampton Branch. Polygon Hotel, Southampton. Thurs., May 17, 7 p.m.
WATFORD
"Electricity in the Oil Industry," by J. Miller. Watford Branch. Compasses Hotel, High-street, Watford. Thurs., May 17, 8.15 p.m.
WEMBLEY PARK
"Atomic Energy in Industry," by A. R. Dixon. North West London Branch. Century Hotel, Forty-avenue, Wembley Park. Mon., May 14, 8.15 p.m.

British Institution of Radio Engineers

LONDON
"The Measurement of the Velocity of 'Light' by Electronic Methods," by K. Froome. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 23, 6.30 p.m.*

British Plastics Federation

LONDON
Discussion on whether a separate section of the Federation should be set up to cover the vacuum forming side of the industry. Meeting open to all interested persons. Tues., May 15, 11 a.m.

Building Centre

LONDON
Films: "An Introduction to Tubular Steel Engineering." Wed., May 16, 12.45 p.m.

Chadwick Public Lecture

LONDON
"Influence of Chadwick on American Public Health," by Dr. Huntington Williams. Royal Society of Medicine, 1 Wimpole-street, W.1. Mon., May 14, 5 p.m.

Chemical Society

DUBLIN
"Applications of Infra-Red Spectroscopy in Chemistry," by Dr. H. W. Thompson. University Chemical Laboratory, Trinity College, Dublin. Fri., May 18, 7.45 p.m.

Corporation of Industrial Managers

LONDON
"Impact of Automation on Management," by E. L. G. Robbins. Charing Cross Hotel, Strand, W.C.2. Mon., May 14, 7.15 p.m.* (Admission by ticket.)

Illuminating Engineering Society

LEICESTER
Annual General Meeting. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., May 14, 6 p.m.
LIVERPOOL
Annual General Meeting. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., May 16, 6 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Legal Aspects of Boiler Operation and Maintenance," by G. A. Anderson. Birmingham Branch. Imperial Hotel, Birmingham. Fri., May 25, 7.30 p.m.
BLACKBURN
Open Meeting. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., May 17, 7.30 p.m.
ROCHESTER
"Air Conditioning in Engineering," by K. W. Dale. Kent Branch. Bull Hotel, Rochester. Wed., May 16, 7 p.m.

Institute of British Foundrymen

COVENTRY
"Investment Casting for Aircraft Engines," by D. F. B. Tedds. Coventry Section. Coventry Technical College, Coventry. Tues., May 15, 7.30 p.m.

Institute of Marine Engineers

LONDON
"The Shipping Industry," by A. Watson. Student Lecture. Mon., May 14, 6.30 p.m.*

Institute of Petroleum

LONDON
"Future of the Petroleum Industry in the United Kingdom," by C. P. Dalton. London Branch. Wed., May 23, 6 p.m.

Institution of Civil Engineers

LONDON
James Forrest Lecture on "Marine Physics," by Dr. G. E. R. Deacon. Tues., May 15, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "An Elementary Presentation of the Principles of Magnetism and Electromagnetic Induction," with demonstrations, to be opened by Professor K. A. Hayes. Education Discussion Circle. Mon., May 14, 6 p.m.*
Annual General Meeting and Film Evening. London Graduates' and Students' Section. Mon., May 14, 6.30 p.m.*
"Mine Locomotives," by T. E. Green. Utilization Section. Tues., May 15, 5.30 p.m.*
"The Sir Adam Beck Generating Station No. 2 at Niagara: A Major Canadian Hydro-Electric Development," by Dr. R. L. Hearn. Supply Section. Wed., May 16, 5.30 p.m.
Annual General Meeting, at 5.30 p.m.* (Open to corporate members and Associates only.) "Appearance Design," by Sir Gordon Russell, at 6.30 p.m. Thurs., May 17.
EDINBURGH
Annual General Meeting. Scottish Centre. Carlton Hotel, North Bridge, Edinburgh. Tues., May 22, 7 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
Annual General Meeting, at 6.15 p.m. Annual Dinner, at 7.30 p.m. North East Branch. Crown Hotel, Clayton-street, Newcastle-upon-Tyne. Fri., May 18.

Institution of Mechanical Engineers

LONDON
Annual General Meeting. London Graduates' Section. Wed., May 16, 6.30 p.m.*
BIRMINGHAM
Annual General Meeting and Chairman's Address. Midland Graduates' Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., May 28, 6 p.m.
LEICESTER
Annual General Meeting and Film Evening. East Midlands Graduates' Section. College of Technology and Commerce, The Newarke, Leicester. Thurs., May 17, 6.45 p.m.

Institution of Mining and Metallurgy

LONDON
Annual General Meeting. Part I, Report of Council. (This part open to Corporate and Non-Corporate Members only), at 4 p.m. Tea at 4.30 p.m. Part II. Presidential Address, by Professor C. W. Dannatt, at 5.15 p.m. Geological Society, Burlington House, Piccadilly, W.1. Thurs., May 17.

Institution of Production Engineers

WOLVERHAMPTON
"The Use of Air-Operated Fixtures in Mass Production," by J. F. Smith. Wolverhampton Graduate Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., May 16, 7.30 p.m.

Institution of Structural Engineers

LONDON
Annual General Meeting. Thurs., May 24, 6 p.m.

Iron and Steel Institute

LONDON
Bessemer Centenary Lecture by James Mitchell. Royal Institution, Albemarle-street, W.1. Tues., May 15, 6.30 for 6.45 p.m. Admission by ticket (no charge).
Annual General Meeting:
Presidential Address, by Dr. H. H. Burton; and Ninth Hatfield Memorial Lecture on "The Fracture of Metals," by Professor N. F. Mott. Royal Institution, Albemarle-street, W.1. Wed., May 16, 9.45 a.m.
Various papers for discussion; and colour film "Steel Road." 4 Grosvenor-gardens, S.W.1. Wed., May 16, 2.30 p.m.
Dinner. Grosvenor House, Park-lane, W.1. Wed., May 16, 7 for 7.30 p.m.
Various papers for discussion. 4 Grosvenor-gardens, S.W.1. Thurs., May 17, 9.45 a.m. and 2.15 p.m.

Royal Aeronautical Society

LONDON
"Medical Aspects of Flight Comfort and Efficiency," by Dr. A. Buchanan Barbour. Tues., May 15, 7 p.m.
Forty-Fourth Wilbur Wright Lecture, by Sir William S. Farren. Royal Institution, Albemarle-street, W.1. Thurs., May 17, 6 p.m.*

Royal Institution

LONDON
"The Structure of Metals as Seen under the Microscope," by

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

*** An asterisk is placed where it is understood that tea is available prior to the time stated.**

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Plastics Federation, 47-48 Piccadilly, London, W.1. (REGent 4681.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chadwick Trust, 90 Buckingham Place-road, London, S.W.1. (SLOane 5134.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Corporation of Industrial Managers. Apply to Mr. C. J. Hatter, 38 Chalkhill-road, Wembley Park, Middlesex. (ARNold 8863.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. (SLOane 0061.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Profes[illegible] S. Smith (University of Chicago). Fri., May [illegible]

Royal Meteorological Society

LONDO[illegible] papers. Wed., May 16, 5 p.m.*
MANCH[illegible]
"Ligh[illegible] by Dr. T. W. Wormell. Manchester Centre. Main B[illegible]ng, The University, Manchester. Fri., May 18, 5.45 p.m.

Royal Society

LONDON
"Resear[illegible] in the Plastics Division of Imperial Chemical Industries, Ltd.," by Dr. J. C. Swallow. Thurs., May 17, 4.30 p.m.*

Royal Society of Arts

LONDON
"Electronic Photography," by Commander C. G. Mayer, U.S.N.R. Peter Le Neve Foster Lecture. Wed., May 16, 2.30 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. "Process Analytical Instrumentation," by A. G. Stanley and J. F. Brown. Manson House, 26 Portland-place, W.1. Tues., May 29, 6 p.m.

Women's Engineering Society

LONDON
Discussion on "Mining Machinery." London Branch. Hope House, 45 Great Peter-street, Westminster, S.W.1. Mon., May 14, 7 p.m.*

MECHANICAL HANDLING

2—TRUCKS AND TRACTORS

Continued from page 318

The Mechanical Handling Exhibition was opened on Wednesday, May 9, and we give below a second report on the machinery and equipment on display. The exhibition closes on Saturday, May 19.

LOAD CLAMP ELIMINATES PALLETS

An increasing range of attachments for enlarging the versatility of trucks and tractors is one of the most noticeable features of the Mechanical Handling Exhibition this year. A new development, known as the Load-Clamp, is shown by Conveyancer Fork Trucks Limited, Liverpool-road, Warrington, Lancashire, designed to permit handling unit loads without the necessity for pallets. During three years of development work, in conjunction with Thomas Hedley and Company, Limited, the Load-Clamp has been successfully tried out on cartons, crates, boxes and cases. It is seen in Fig. 6.

The clamp is hydraulically actuated. To avoid damaging the loads by clamping pressure, an adjustable pressure-control valve is incorporated which permits the truck driver to select the optimum pressure for the load to be handled. The steel grip plates have double articulation to compensate for any slight irregularites in the unit load itself. The arms are so designed that loads can be stacked with a vertical gap between the stacks of only 3 in.

Another interesting exhibit by Conveyancer is the second prototype Overlander fork-lift truck suitable for handling materials and equipment over long distances and in open country, and at speeds over 30 m.p.h. on normal roads. The first prototype machine was described in the September 2, 1955, issue of ENGINEERING (page 316).

FORK-LIFT TRUCK FOR LONG LOADS

A new type of fork-lift truck designed for handling long loads such as timber, steel sections, and pipes, is exhibited by Ransomes and Rapier Limited, Waterside Works, Ipswich, Suffolk,

Fig. [illegible]ork-lift truck with slewing mast for hand[illegible]ng loads: Ransomes and Rapier Ltd.

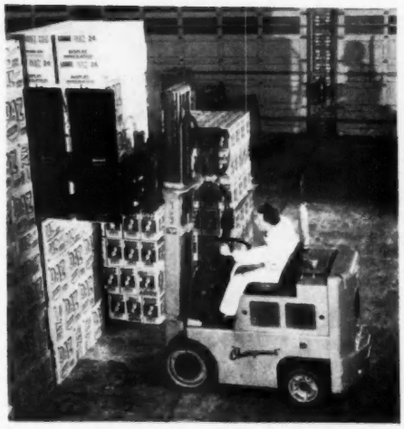

Fig. 6 Load clamp for handling cartons and crates without pallets: Conveyancer Fork Trucks Ltd.

known as the Rapier Super fork truck. In this machine, the mast is arranged to swivel to one side so that, for travelling, the load is disposed with its axis parallel to the direction of travel. The load is picked up in the conventional manner with the mast in front of the cab. After loading, a combined steering and slewing manoeuvre withdraws it from a line of sets so that it finishes in the position shown in Fig. 7.

With the slewing mast, the truck can enter a transverse lane between sets, pick up a load at the end, back out with it into the main gangway and manoeuvre into its travelling position. The Super fork truck, which has ample power for hill climbing, has a maximum road speed of 20 m.p.h. and a lifting and carrying capacity of 12,000 lb. at 24 in. from the face of the forks. The distance between the forks is adjustable to suit the load over the range 3 ft. 2 in. to 5 ft. 6 in. The lifting and lowering speeds are 35 ft. per minute and 60 ft. per minute, respectively.

The lifting, tilting and mast slewing motions are all hydraulically actuated. The maximum lift height is 12 ft. 6 in. The range of tilt of the mast is from 10 deg. forward to 6 deg. backward; with the mast vertical, the forks are set 6 deg. back. The slewing range is from straight ahead to 90 deg. to the left.

A single lever controls interlocks which ensure that the tilt and slewing motions cannot be operated together; that slewing cannot be performed until the mast and trolley have been raised sufficiently to clear the chassis, and then only if the mast is vertical; that the mast and trolley cannot be lowered until slewing is complete; and that the slewing and non-slewing portions of the inner mast are correctly aligned when the trolley is in the straight-ahead position, enabling hoisting and lowering to be carried out normally.

The truck is driven by a 70 h.p. Perkins P.6 Diesel engine through a Borg and Beck clutch and a gearbox giving three speeds forward and three reverse, thence through a chain drive to a two-speed axle which is locked in either high or low gear. At low speeds Stokes self-steering provides for effortless control and rapid manoeuvring, the truck has a turning circle radius of only 12 ft. 3 in.

STRADDLE CARRIER CRANE

At intervals throughout the day, the British Straddle Carrier Company, Limited, 7 Chesterfield-gardens, Curzon-street Mayfair, London, W.1, are demonstrating outside the exhibition hall a Steelmaster Mark 1A straddle carrier fitted with the new 30 cwt. straddle-carrier crane. The straddle carrier system, which was described in the November 26, 1954, issue of ENGINEERING (vol. 178, page 707), was devised for handling long bulky loads up to 60 ft. long, such as pipes, rails, etc., more quickly and economically than is possible by the tractor/trailer method. The Steelmaster 1A is self-loading and unloading in 4 seconds, and has a travelling speed of 25 m.p.h., forward or reverse. The average working load recommended by the manufacturers is 16,000 lb.

With the crane attachment, illustrated in Fig. 9 on the following page, the driver can load or unload individual loads direct from a road or rail vehicle, and can form them into a main load which the carrier can then transport in the normal way. The crane can also be used for pipe laying.

The telescopic jib is made in three sections, and has the following capacities: with a jib length of 5 ft. 6 in., 30 cwt. can be lifted 12 ft. 9 in. from the ground; with a jib length of 8 ft. 6 in., 16 cwt. can be lifted 14 ft. 7 in.; and with a jib length of 11 ft. 10 in., 10 cwt. can be lifted 15 ft. 9 in. The crane can be slewed through 180 deg. Hoisting and slewing are hydraulically actuated and are controlled from a single lever in the driver's cab. A safety mechanism prevents overloading and the dropping of the material being handled.

FROM CONVEYOR TO PALLET

Displayed on the stand of Paterson Hughes Engineering Company, Limited, Bedford-street, London, W.C.2, is the Palletiser manufactured under licence from the J. W. Greer Company, Wilmington, Massachusetts, U.S.A., and marketed jointly by the Paterson Hughes company and Lansing Bagnall Limited, Basingstoke. This

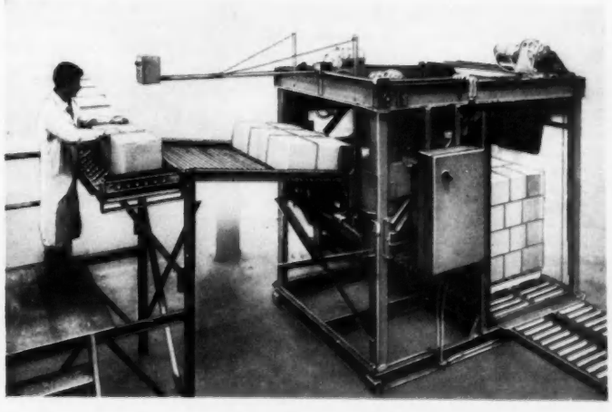

Fig. 8 Palletiser used for transferring goods from conveyor to pallet: Paterson Hughes Engineering Co. Ltd.

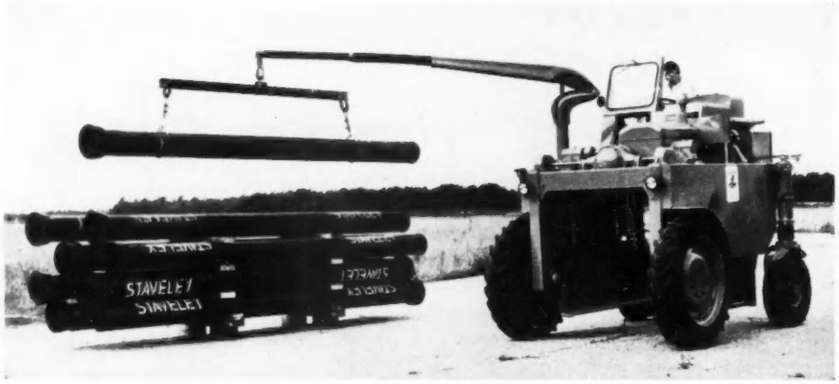

Fig. 9 Steelmaster straddle carrier with crane attachment: British Straddle Carrier Co. Ltd.

machine is designed for transferring goods, after manufacture, from the roller conveyor system to the unit load or pallet system used for stacking in stores—an operation which, hitherto, has constituted one of the main bottlenecks in the smooth flow of goods. The Palletiser is electrically operated, and weighs 7,500 lb.

To operate the Palletiser, which is illustrated in Fig. 8, only one man is needed. He stands on a raised platform at one side of which a roller conveyor delivers the goods to be palletised on to a rotating-ball arranging table in front of him. Either right or left conveyor feed machines are available. An empty pallet is delivered into the rear of the machine from a magazine. The operator swings the cartons or boxes on the ball table to make row after row, arranging a layer of goods the size of the pallet to any pre-arranged pattern and assembling it on the inclined roller table beyond the ball table. On pressing a push-button the layer of goods is released into the machine, when the loading carriage passes it over the pallet. A sensing plate automatically adjusts it to the correct height and the carriage slowly retracts, leaving the layer of goods neatly in position. By the time the carriage has fully retracted the operator has another layer ready for release.

The loading carriage places layer upon layer to a maximum height of 66 in. The machine will accommodate pallets ranging in size from 32 in. by 32 in. to 48 in. by 48 in. and intermediate combinations. The maximum height of packs handled is 24 in., although machines for larger loads and pallets can be specially constructed. Completed pallet loads are discharged from the Palletiser automatically on to a roller conveyor, where they can be readily lifted away by fork or pallet truck. Another empty pallet is then released from the magazine.

Where several production-line conveyors are discharging articles or packages of different sizes into one loading stream, it can be arranged by " stop-off " controls for the operator to accept these alternately at will, as changes in package size can be made at any time without alteration to the Palletiser setting. The magazine attached to the machine holds 12 pallets, and is fitted with an indicator to warn the operator when the supply of empties is low. A selector switch pre-sets the number of tiers to be loaded on each pallet.

TOOL AND DIE HANDLING TRUCK

For handling heavy and awkwardly shaped tools and dies and transporting them from the store to the press, Matling Limited, 28 Caxton-street, London, S.W.1, in conjunction with Talbot-Ponsonby and Company, Limited, Langrish House, Langrish, near Petersfield, Hampshire, have developed a new tool and die-handling truck.

The truck is powered by a standard Matling power unit, either battery or mains operated, which incorporates the hydraulic system actuating the lifting jack which raises or lowers the platform on which the load is carried. The platform is 34 in. wide by 32 in. deep and its height when fully lowered is 8½ in. and when fully raised 53 in. The truck is available in 2 or 3 tons capacities.

The load is transferred on to and off the platform by means of a Talbot-Ponsonby " pull-on/push-off " attachment, comprising a pair of conveyor chains driven through a reduction gearbox by a hand crank (Fig. 10). An angle bar on the on/off attachment together with a chain sling provide for getting the load off and on to the conveyor. Slots are provided on the mast-section, carriage and on-off attachment for the lashing chain which is used for manipulating the load and securing the machine to a pallet or press when unloading.

DRUM AND CYLINDER CARRIERS

A new hand truck for carrying paper reels and oil drums is displayed by Omic Limited, 9 George-street, London, W.1. It incorporates the standard hydraulic unit of the Paliton hand-pallet truck, thus ensuring quick availability of spare parts. A few strokes of the combined tow-handle and pump lever raise the load 5 in. from the ground, ready for moving.

Handling of drums by fork-lift truck is greatly simplified by the use of the company's multiple-drum carrier. The heavier the drums, the tighter they are gripped. The drums can only be released by applying hydraulic pressure, and are thus held securely and safely until they are deliberately released. Carriers are available to handle two, four or six drums, with a variation of 2 in. in diameter and 6 in. in height, thus accommodating standard drums normally in use.

The cylinder carrier (Fig. 11) for handling gas cylinders by fork-lift truck operates on the same principle as the drum carrier. The standard cylinder carrier handles 12 cylinders of 15 in. diameter, but models to suit other sizes and quantities can be readily supplied.

Among other trucks and tractors exhibited for the first time at the Mechanical Handling Exhibition are a lightweight wheeled tractor for industrial use by Ransome Sims and Jefferies, Limited, Orwell Works, Ipswich, available with an attachment for shunting railway trucks; a 2,000 lb. industrial truck powered by a 3½ h.p. Lister air-cooled Diesel engine, shown by R. A. Lister and Company, Limited, Dursley, Gloucestershire, available in two-gear or single-gear versions with maximum road speeds of 7·4 m.p.h. and 5·2 m.p.h. respectively; an industrial tractor with a drawbar pull of 3,700 lb. powered by a 41 h.p. petrol engine with a six-speed gearbox and a maximum road speed of 25 m.p.g., shown by David Brown Industries, Limited, Huddersfield, Yorkshire; and a high-lift hand-operated pallet transporter shown by I.T.D. Limited, 95-99 Ladbroke-grove, London, W.11.

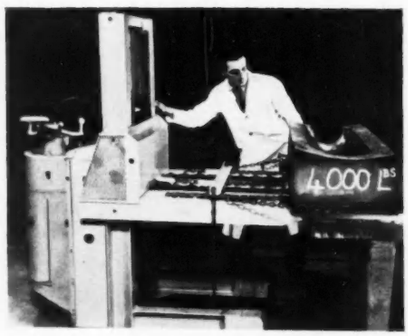

Fig. 10 Tool and die handling truck with " on/off " loading attachment: Matling Ltd.

The Yale and Towne Manufacturing Company, Limited, Wednesfield, Wolverhampton, Staffordshire, are showing their Platform Warehouser, a 2 ton low-lift truck designed to move loads at high speeds in congested factories, equipped with a " dead man " control which cuts off power and applies the brakes when the operator steps off the truck; three new electric fork lift trucks with capacities of 4,000, 6,000 and 8,000 lb.; and a hydraulic hand-lift truck undergoing a repeated load test which has already been in progress for several months.

Among the wide range of pallets and stillages on view, Victrolec Limited, 263 Victoria-road, Aston, Birmingham, 6, are showing several new developments. Their drop-bottom box pallet is designed for use with a service stand to feed components directly to the operator's hands; the hopper is designed to give either right-hand or left-hand feed, or to feed to both hands for two operators. They are also showing a " ventilated pallet " for hot forgings and stampings, and a new type of tote-box racking designed on the unit principle, in tiers of three, four or five for stacking to any desired height and for maximum flexibility.

Fig. 11 Gas-cylinder carrier: Omic Ltd.

To be continued

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ELECTRICITY SUPPLY STATISTICS

Effect of Weather Conditions

During March, 6,535 million kWh were sold by the Central Electricity Authority to the English and Welsh Area Boards. This was actually a decrease of 0·4 per cent. compared with the output in March, 1955. When corrected for weather conditions and the number of working days there was, however, an increase of 8·8 per cent., which compares with the figure for the previous month.

The amount of electricity sent out by the Area Boards during March was also 6,535 million kWh, of which 174 million kWh were supplied direct by the Central Authority. The decreases in the amounts sent out were 0·4 per cent. in the " mainly industrial " and 1·5 per cent. in the " mainly non-industrial " areas, when compared with those of the previous year.

In Parliament

HELICOPTER SERVICES

Problems concerning the development of inter-city helicopter services were raised during a recent sitting of the House of Commons. In reply to Mr. Roy Mason (Labour), who asked what approaches had been made by civil airlines for the recognition of inter-city helicopter routes by the Ministry of Transport and Civil Aviation, Mr. Harold Watkinson said that only one such application had so far been received. That had come from British European Airways and they sought permission to operate an inter-city service linking Birmingham, Leicester and Nottingham. The Minister added that a pamphlet had been made available to local authorities by his Department last year giving up-to-date information on the requirements for governmental recognition of helicopter sites.

The Birmingham-Leicester-Nottingham service was largely experimental and was only operated on a limited basis. Accordingly, it had not been possible to include in it all the towns in the Midlands that possessed suitable landing sites. Mr. R. T. Paget (Labour) suggested that Northampton should have been included in the service, as it had reserved a helicopter landing site close to the town centre that was capable of being used by single-engined helicopters without flying over built-up areas. Mr. Watkinson said it was understood that the B.E.A., after a careful review of operating costs and traffic potentials, had decided that the route chosen, between Birmingham, Leicester and Nottingham, was the one which was likely to make the most valuable use of the limited resources available to the Corporation. The matter had been gone into very carefully.

TWO-ENGINED HELICOPTERS

Research in connection with two-engined helicopters is proceeding. The Minister of Supply, Mr. Reginald Maudling, told Mr. Mason that development work continues on the Fairey Rotodyne, as well on the Bristol 173 and its military variant, the 192. With respect to the Bristol helicopter, Mr. Maudling said, it was the Government's intention to get a gas-turbine version into service as quickly as possible, and a production order had been placed recently for the Gazelle engine. The B.E.A. were showing an interest in the Bristol 173 and the Ministry of Supply had arranged to lend the Corporation one of the prototypes of that machine for experimental flying to be conducted on it later this year.

ENGINEERS IN GOVERNMENT EMPLOY

The Minister of Labour and National Service, Mr. Iain Macleod, informed Mr. Austen Albu (Labour) that the inquiry being carried out by the Social Survey into the employment and distribution of engineers and scientists was confined to an investigation of those in private industry. A similar investigation covering men employed in these capacities by Government Departments, the United Kingdom Atomic Energy Authority, the nationalised industries and other main users of scientific manpower was being conducted by the Ministry of Labour. Information regarding the numbers and types of engineers and scientists called up for National Service was already available.

Asked by Mr. Albu if he was aware of the general concern about this matter and whether his Department was taking the problem sufficiently seriously, the Minister said that the maintenance of a proper balance between engineers and scientists in the armed forces and in civilian industry was one of the most important aspects of the whole call-up arrangements. He told Mr. James Callaghan (Labour) that he would publish the results of his Department's inquiry into this matter when available, subject to the reservation that some aspects, relating to the Atomic Energy Authority and other establishments, might be governed by security considerations.

"DILUTEES"

The recognition of engineering dilutees was raised by Dr. D. Johnson (Conservative). He asked if the Minister of Labour was aware that a number of men employed as aircraft fitters at Kirkbride had accepted training from his Department for that work on the assurance that they would be fully recognised as skilled men, and that these workpeople included ex-trainees of the Department who had given satisfactory service for over 16 years in skilled employment.

Mr. Robert Carr, the Minister's Parliamentary Secretary, replied, in a written answer, that such an assurance would not have been given to any man who accepted a Ministry of Labour vocational training course in engineering. There was nothing to be added to the answer he made to Captain H. B. Kerby (Conservative) on March 23 last. In this, Mr. Carr stated that the general conditions on which unemployed men were offered the Ministry's vocational-training courses before the war were known to the Ministry. It would have been made perfectly clear to the men in question that they would be in competition with apprenticed-trained craftsmen and that their employment would consequently be subject to whatever terms and conditions might from time to time be agreed upon between the two sides of the industry.

Comet Aircraft Repurchases

Air Commodore A. V. Harvey (Conservative), who inquired as to the price paid for two Comet aircraft taken back from Air France, was told by Mr. Reginald Maudling, Minister of Supply, that two Comet aircraft taken back by the manufacturers from Air France, and the shell of another, had been ordered by his Department at a total cost of £560,000. That sum included the cost of overhauling and of making the substantial modifications necessary to render these aircraft suitable for the Ministry's use. These results could not have been obtained in any other way, except at even greater cost.

Greenwich Research Station

Mr. Albert Roberts (Labour) asked the Prime Minister if he would consider transferring the control of Greenwich Research Station to the Ministry of Fuel and Power. Sir Anthony Eden replied that certain changes in the administration of the Department of Scientific and Industrial Research were being proposed in a Bill which had recently come to the House of Commons from the Upper Chamber. Matters such as that referred to would no doubt be considered by the executive council which it was proposed to establish under the terms of that Bill. Mr. Callaghan asked if it were not the case that the principal achievement of the Greenwich station, during the past 20 years, had been to show how to produce oil from coal and suggested that it would be advantageous if the reverse process, of obtaining coal from oil, might now be studied. Sir Anthony reminded him that both substances were burnt in about equal proportions.

Report on Technological Awards

In reply to Mr. Albu, who asked the Minister of Education when he expected to receive the report of the National Council for Technological Awards, Sir David Eccles said that the National Council was an independent body and was not required to report to him. He understood that the National Council proposed to issue in the near future a memorandum setting out the conditions on which it would recognise courses in technical colleges leading to the Diploma.

Director of the Science Museum

In answer to Mr. Albu, who asked for information about the appointment of the Director of the Science Museum, Sir David Eccles stated that the vacancy had been advertised by the Civil Service Commission and that applications were being considered. The salary was £2,325 a year, which was somewhat lower than that paid to the Director of the British Museum, for instance, but it would be better to await the result of the applications that had been made before considering any alteration.

Oil-Burning Factories

Viscount Lambton (Conservative) was told by Mr. Aubrey Jones, the Minister of Fuel and Power, that full information was not available regarding the number of existing factories which had been equipped to use oil instead of coal in the North-Eastern Region of England. Returns collected from the larger industrial undertakings, accounting for about 90 per cent. of the total fuel consumption by industry, showed that 22 per cent. of them in the Northern Region, 38 per cent. in the Eastern Region, and 35 per cent. in the South Western Region, used oil for burning to a greater or less extent.

Workers Employed on Armaments

Particulars were sought by Mr. James Johnson (Labour) as to the approximate numbers of workpeople at present engaged on the production of armaments and in ancillary activities. He was informed by Mr. Macleod that it was estimated that there were about 770,000 persons engaged in these pursuits at the end of last year. That figure included persons engaged on defence orders placed by Government Departments on behalf of countries overseas.

Heavy Opencast Mining Machinery

In view of the decision of the National Coal Board to continue opencast coal mining until 1965 and beyond, Mr. G. Nabarro (Conservative) asked for steps to be taken to encourage the production of the required machinery in this country, in order to minimise dollar imports. He was informed by Mr. A. R. W. Low, Minister of State to the Board of Trade, that British manufacturers already produced a wide range of heavy opencast mining machinery and he was sure that they would keep in close touch with the National Coal Board. That organisation and its civil engineering contractors were subject to the same import licensing rules and import duties as private firms.

Coal Industry Statistics

Information on various matters relating to the coal industry were provided by Mr. David Renton, Parliamentary Secretary to the Ministry of Fuel and Power, in written answers to questions by Mr. J. Ridsdale (Liberal and Conservative) and Mr. G. Nabarro (Conservative). The Minister stated that the industry's labour force at present numbered 706,000 men, which was 7,000 fewer than its immediate requirements. Some 17,200,000 tons of coal were imported during the years 1947 to 1955 inclusive and were supplied by the National Coal Board at an average cost of about £2 8*s*. a ton more than the proceeds of resale. These extra costs, however, were more than balanced by the premiums obtained during the same period on the coal exported abroad. Thus, if the Board's oversea trading was considered as a whole, it had reduced rather than increased the accumulated loss sustained by that body.

Flammability of Materials

The Home Secretary, Major Gwilym Lloyd-George, assured Mrs. Jean Mann (Labour) that the Government's Inter-Departmental Committee on Home Safety had carefully studied the research work done by the Department of Scientific and Industrial Research on the flammability of materials. The test devised by the D.S.I.R. for flammability of thin flexible materials had been incorporated in a British Standard. This was simply a method of testing, however, and wider publicity for it would not, by itself, reduce accidents. The committee attached greater importance to the finding of a cheap and effective method of flame-proofing clothing materials, and the efforts to that end now being made by the clothing trade were very welcome.

THE HUMAN ELEMENT

Airline employees' reactions to their new leaders—A rational wages structure for the newest industry—Engineering union becomes involved in the equal pay issue—Actual earnings and nominal wage rates are not always in step—State pensions discourage the elderly worker—Double pay on Sunday has lost its meaning but not its attractions.

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Employees and the Two Airlines

Statements by employees of B.E.A. and B.O.A.C. last week have made it quite clear that they have every intention of playing a part in influencing the policies of the two airlines. First, there was the meeting at London airport of 100 delegates of B.O.A.C's 6,000 employees, who passed a vote of no confidence in their new chairman, Mr. d'Erlanger, and in the Minister who appointed him, Mr. Watkinson. The part-time nature of the appointment " at a time of fierce world competition " was severely criticised, as also was Mr. d'Erlanger personally: " because of his attitude to public ownership we view with extreme disquiet the appointment of a man who in the past has proved to be a failure in a similar appointment with B.E.A." The resolution then recalls that Mr. d'Erlanger was removed by the Minister " with the support of the trade union side of the National Joint Council of the airline corporations." To this can be added the " open letter " to Mr. Watkinson stated to have been written by 12 senior pilots of B.O.A.C. and who recorded their dismay and lack of confidence in the appointment of the chairman and deputy chairman, " whose last experience of practical flying was 40 years ago."

Finally, there is the stern warning by Mr. J. Matthews, secretary of the trade union side of the National Joint Council, and normally a most reserved union leader, that all B.O.A.C. aircraft would be grounded at once if the Government or anyone else tried to " whittle away " the Corporation or to prevent its expansion. The trade union members of the Joint Council endorsed the motion of no confidence in the appointments and in the Minister which was passed by the shop stewards at London Airport.

The rallying in strength to the defence of nationalisation and of Sir Miles Thomas' policies when he was B.O.A.C's chairman is certainly impressive. The watchful and suspicious attitude of union leaders is a marked change from the co-operative spirit which has prevailed until now in both airlines. B.E.A. union representatives, the Association of Supervisory Staffs Executives and Technicians, have banned all overtime supported by parallel action by B.O.A.C. representatives on the question of maintenance and inspection of Viscounts and Elizabethans. The unions claim that B.E.A's proposals to sub-contract this type of work outside London airport and to employ charge-hands instead of inspectors to " sign out " aircraft is lowering the standard of maintenance and dangerous to the airlines' customers. The management deny that anything unusual has been done and say that the union's claim is nonsense.

The whole position is explosive: at the back of the men's minds is clearly the possibility of a merger of B.E.A. and B.O.A.C. and subsequent de-nationalisation. Mr. d'Erlanger has denied it.

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Agreement on Atomic Pay

Uniform national minimum wage rates for the 14,000 manual workers employed by the Atomic Energy Authority were agreed by the industry's Joint Industrial Council at a meeting held last week. Both sides are to be congratulated in taking the opportunity they had as a new industry to set up a uniform structure of wage rates and working conditions. These rates, which cater for differentials—a minimum of £10 per week for skilled and £8 5*s*. for unskilled was claimed by the unions—and which define clearly the relationship between type of work and earnings, should go far to avoid the many difficulties to which older industries are exposed. The large number of unions, and their example of tidiness and applied logic, may help to bring about a more constructive attitude on the part of the trade union movement to standard wage policies in other industries, handicapped by their age and traditions.

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Equal Pay for Women Again

There is a certain amount of masculine circumspection developing in the engineering industry on the issue of equal pay for women. A letter has now been received by the unions concerned in response to their request for an official inquiry into the matter, saying that it is up to the industry to decide whether there should be an inquiry. The Ministry also take the view that the industry should carry out the investigation if it considers that one is desirable. Mr. Scott said at a meeting of the five unions concerned last week that " surprise and concern " had been expressed at the official view, the inference being that the unions would have to organise a dispute in order to get a Court of Inquiry.

This was rather a laboured interpretation to put on the official attitude and the unions have thought better of it. The employers are now to be asked by the unions to join them in an inquiry on the work and conditions of the 40,000 women employed in the engineering industry. In the end, then, the knights of the negotiating table are trotting rather stiffly and reluctantly into the lists to run a course for the ladies. The issue is not likely to be the major one for the industry in 1956, for there are already serious moves afoot to put a further general wage claim before the employers in the autumn. Nevertheless, once started, it may be difficult to shelve. Unions have usually been careful about forcing the issue of equal pay too far in case it rebounded unfavourably on the main, masculine body of their membership. A gain for equal pay in engineering would, however, be a major tactical gain for equal pay as a whole.

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Wage Rates and Earnings

Of recent years, the rate of increase of workers' earnings has been remarkably uniform, much more so than the rate of increase of wage rates. This is one of the points made in an article in the latest *Bulletin for Industry* on wages statistics. It is of particular interest that the upward movement of earnings was hardly interrupted even at the time of wage restraint in 1949. The movement of wage rates quite definitely came to a halt at that time but the slow-down in the advance of earnings was barely perceptible.

There have been two periods in the last eight years when earnings have gone ahead of the trend of wage rates. There was the short-lived period of wage restraint under Sir Stafford Cripps and there was the upswing of the last boom in 1954. The gap in the latter period is fairly easy to understand from the available figures. As industrial activity increased, the additional output was obtained by increasing overtime and by reaping the benefits for various kinds of payment-by-results schemes. The earlier divergence is rather more difficult to interpret. At first sight it would seem that the policy of wage restraint was a failure, for earnings went on growing, probably becaue of overtime. It is, of course, possible that the rate of earnings reflected a genuine corresponding increase in output but this could be true only to a limited extent. On balance it is likely that industry got the additional production by paying something like time-and-a-half on the average. At best, wage restraint seems to have been a half-success. It underlines the lesson which everyone is reluctant to learn, namely, that you cannot keep the lid on a kettle when you boil water without a proper outlet for the steam.

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A Niggardly Award

The National Insurance Advisory Committee recommend certain changes in the earnings rule governing retirement and other pensions in a report to the Minister of Pensions and National Insurance which he has now accepted. A worker or widow will thus be able to draw full pensions even if they continue work, provided they do not earn more than 50*s*. a week. Between 50*s*. and 70*s*. a week, they will lose 6*d*. instead of 1*s*. for each 1*s*. earned. Beyond 70*s*. the old one-for-one rule will apply. This would mean that a pensioner whose net earnings are £4 per week could still draw a pension of 20*s*. and that he could earn up to £5 per week before his pension is entirely withdrawn.

To make the full payment of pensions on retiring age without any earnings conditions would cost the Exchequer £76 million a year. This, presumably, is the extent to which the earnings rule is not evaded. That evasion takes place on a large scale was admitted for the first time in a report on the earnings rule issued last week. Thus we have an incentive to remain idle when the country needs as many workers as can be found and a penalty on " strictly honest" people. Moreover, it is an unjust situation, since retired businessmen or service officers are allowed to earn as much money as they can without forfeiting any part of their professional pensions.

If the country is so poor as not to be in a position to forego the £76 million a year, and if most old people do, in fact, earn their living, why not pay less pensions initially, say half, at the minimum age and the whole three or four years later? The committee's terms of reference (2 of the 9 members dissented) prevented them from making such a suggestion, which was put forward last year by Professor Cairncross in his reservation to the Phillip Committee's report.

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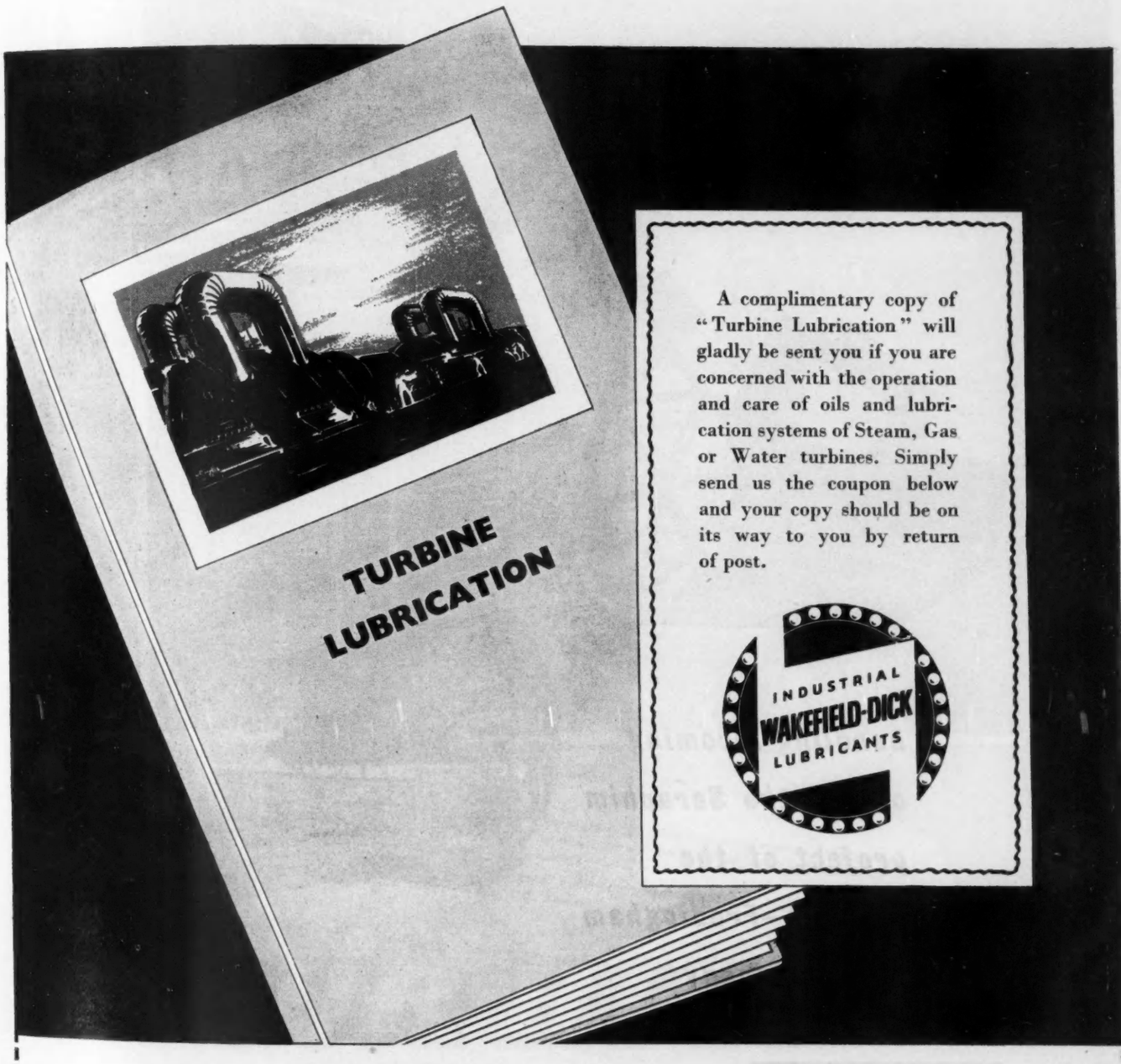
Double Pay on Sunday

Correspondence in *The Times* has rightly drawn attention to the dangerous muddle which has developed of recent years about Sunday working. Originally, during the war, it was countenanced as a means of getting extra output in an emergency. To help men take a risk on their scruples and those of others about the purpose of Sunday, either religious or recreational, they were offered in most cases double pay. Now, very often, double pay on Sunday is taken as a dodge to work less hard during the week.

But the issue is complicated. Some industries require Sunday working by reason of the process worked. Sabbath-breaking for gain, whether viewed on religious grounds or as lost leisure time urgently needed by all workers in this complicated age, is basically a challenge to management. Condoning with the seven-day week must usually mean slackness on one at least of them, and hence higher costs. This year could be an opportune time to face the problem. There is likely to be a reduction of overtime in many industries and a demand for the work available to be spread over the existing labour force. This development, together with improved management methods, could be the way out. For over a century there has been a humanitarian influence at work in British industry, fighting against social cannibalness in these matters. It saved children and women from the pits and brought education to the half-timers. The challenge to-day is more insidious. It asserts that a man is at his most useful to himself, his dependents and to everyone else when he is lounging on the job or feverishly keeping up with a machine.

For all who
OPERATE TURBINES



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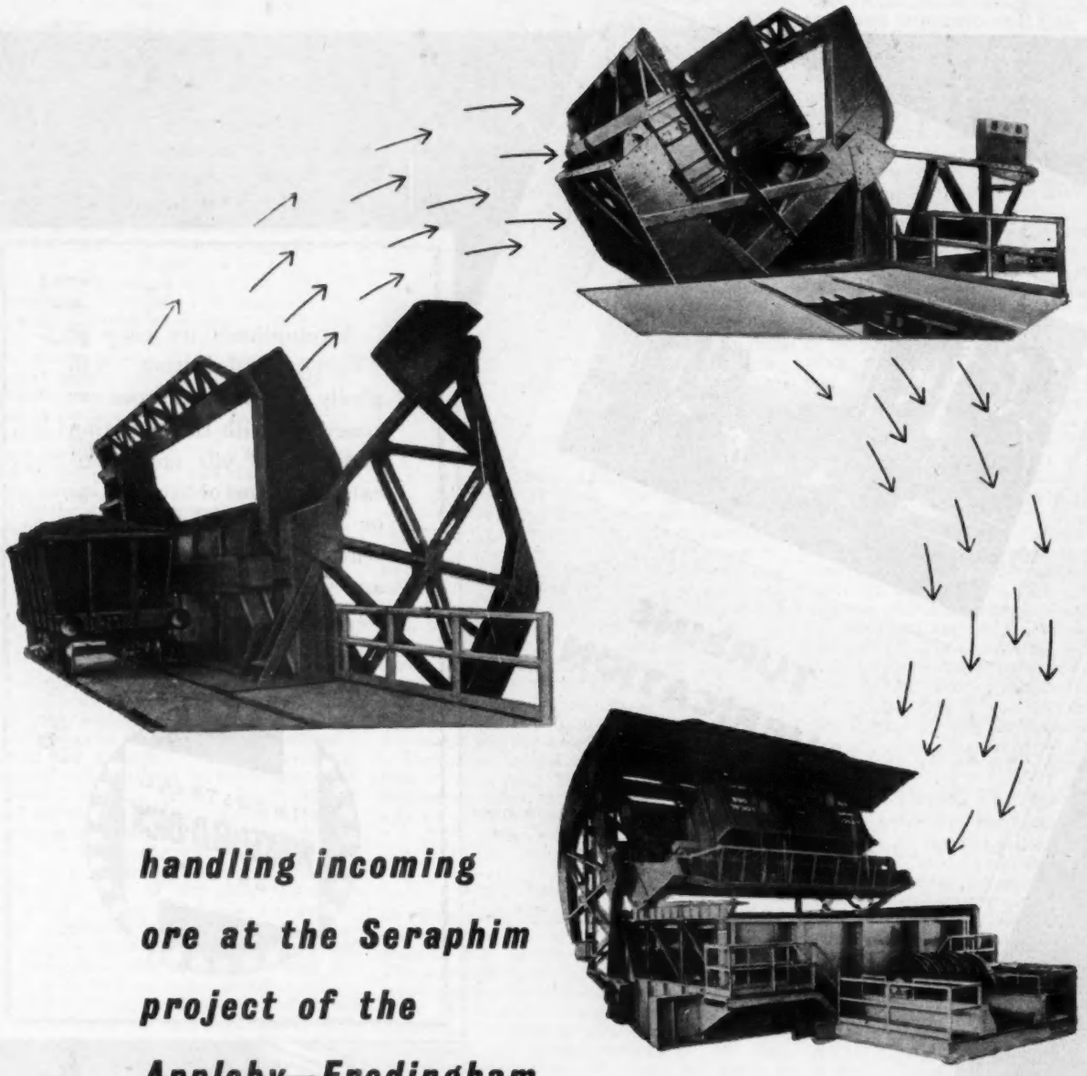

handling incoming ore at the Seraphim project of the Appleby—Frodingham Steel Company

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The above photograph illustrates a Robertson Four-High Sheet Mill installed at Messrs. Samuel Osborn & Co., Ltd., Sheffield.

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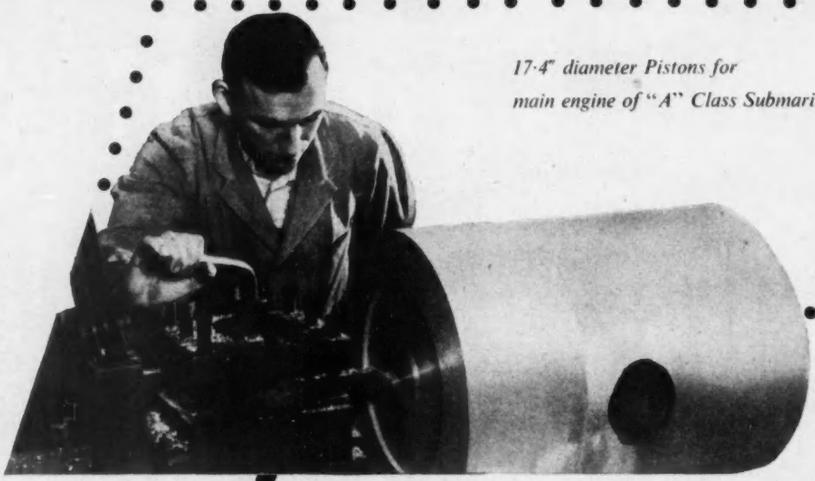

17·4" diameter Pistons for main engine of "A" Class Submarine

Photograph by courtesy of Vickers-Armstrongs Ltd.

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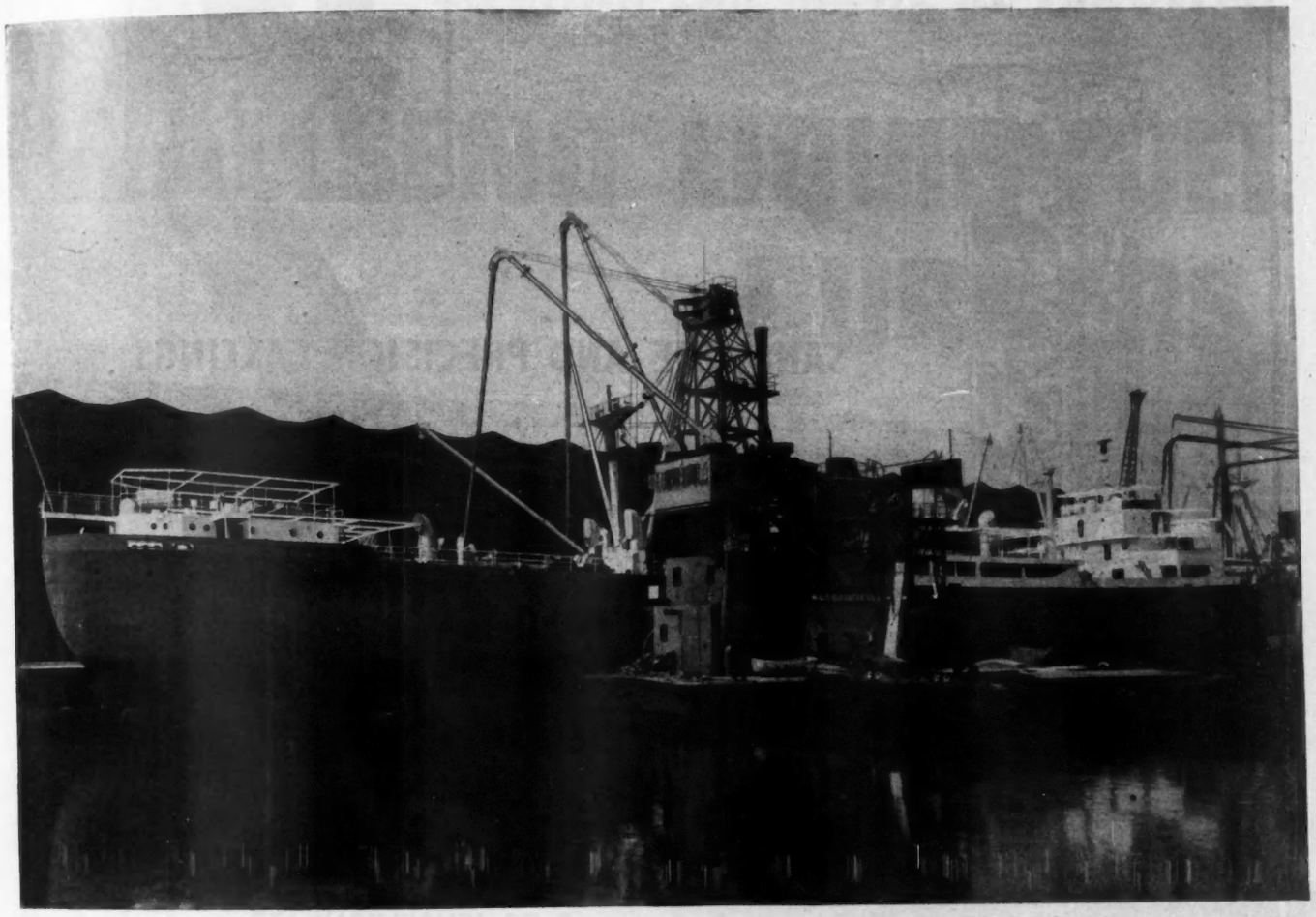
FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS.

Britain's latest grain unloading equipment



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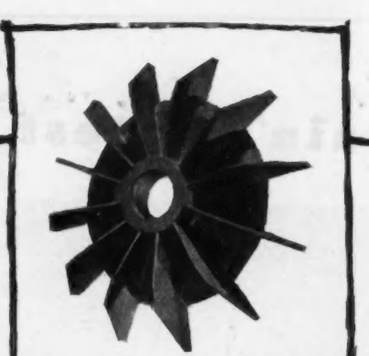

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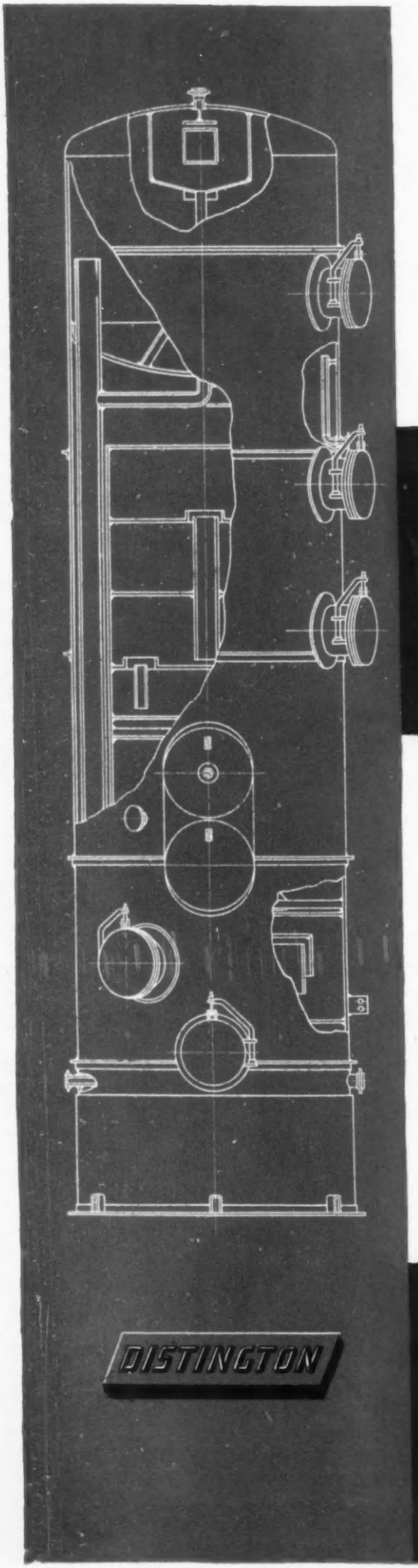

Steelwork fabricated by

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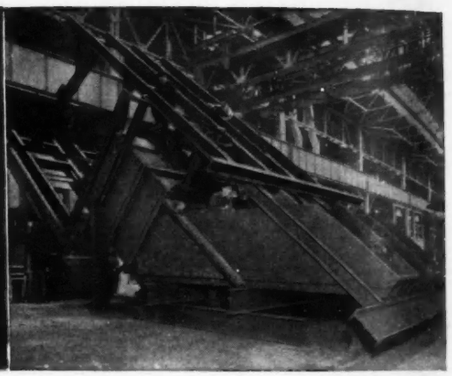


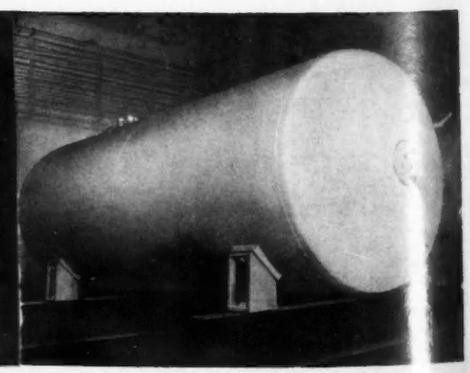
(*above left*) Draught tube cones produced for The English Electric Company Limited, and used in an important hydro-electric installation overseas.

(*above right*) Ore loading pocket with lining plates of 12% manganese steel. The pocket was dismantled, and re-assembled at a mine overseas.

(*below left*) Solid bottom mine car of 3½ tons capacity, fitted with automatic couplers, roller bearing wheels, laminated springs, and ramming face attachments. The body was fabricated from medium tensile corrosion-resisting steel. Distington Engineering Company has a large department devoted entirely to the flow production of mine cars.

(*below right*) Air receiver, an example of the many types of cylindrical vessel produced with the assistance of automatic welding machinery.

Distington Engineering Co. Ltd. has excellent facilities for machining medium and heavy components, and for the production of iron castings also in the medium and heavy categories.



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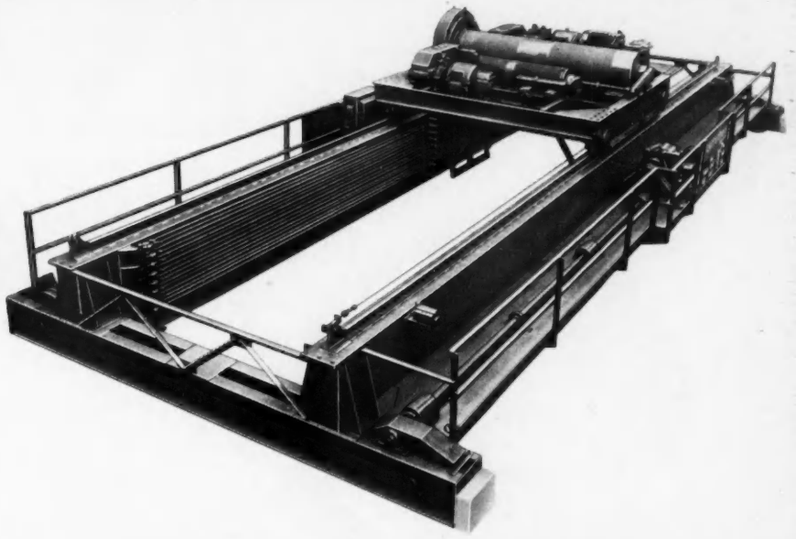

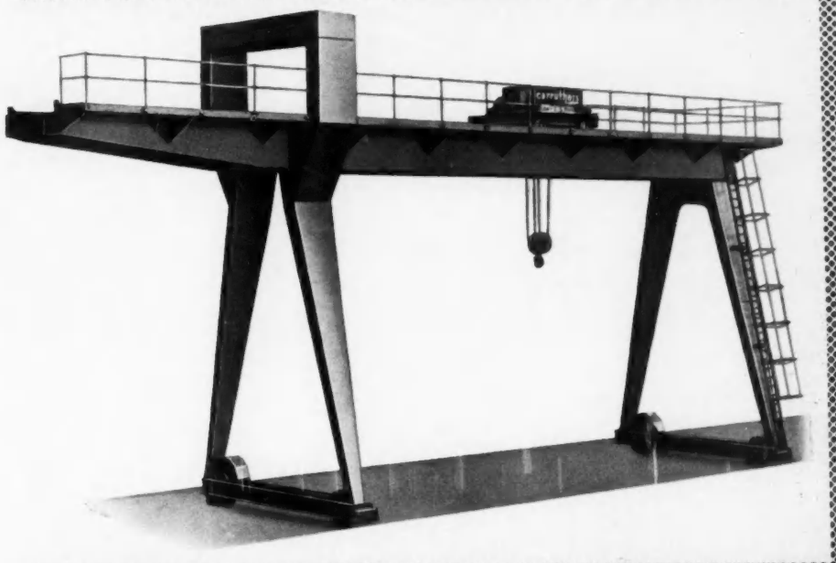

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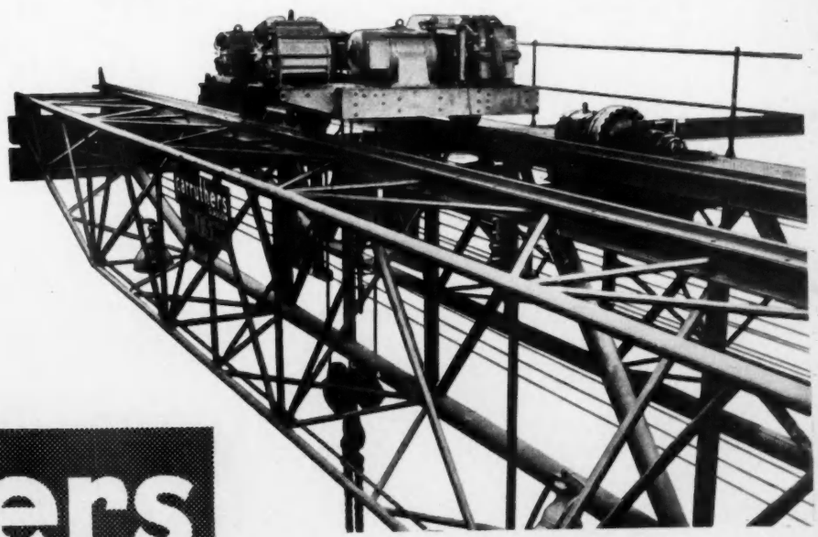

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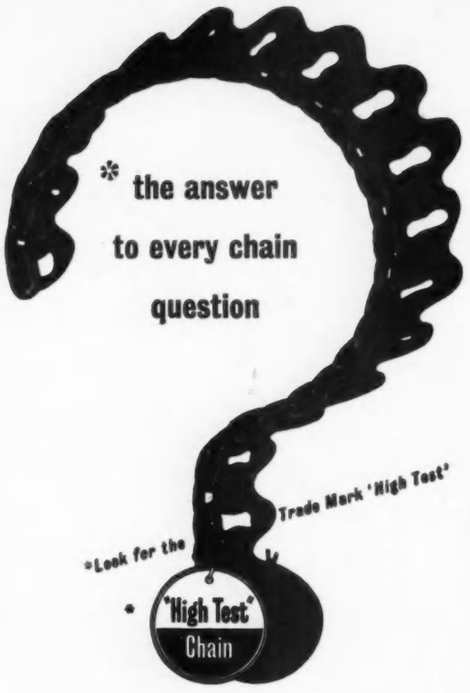

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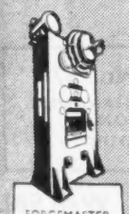
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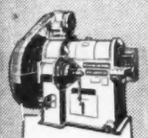
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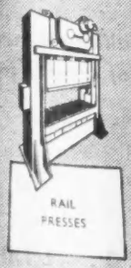
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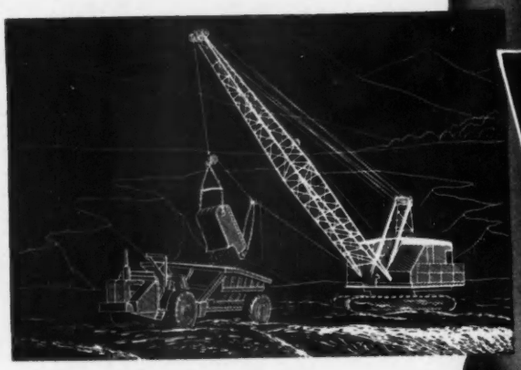

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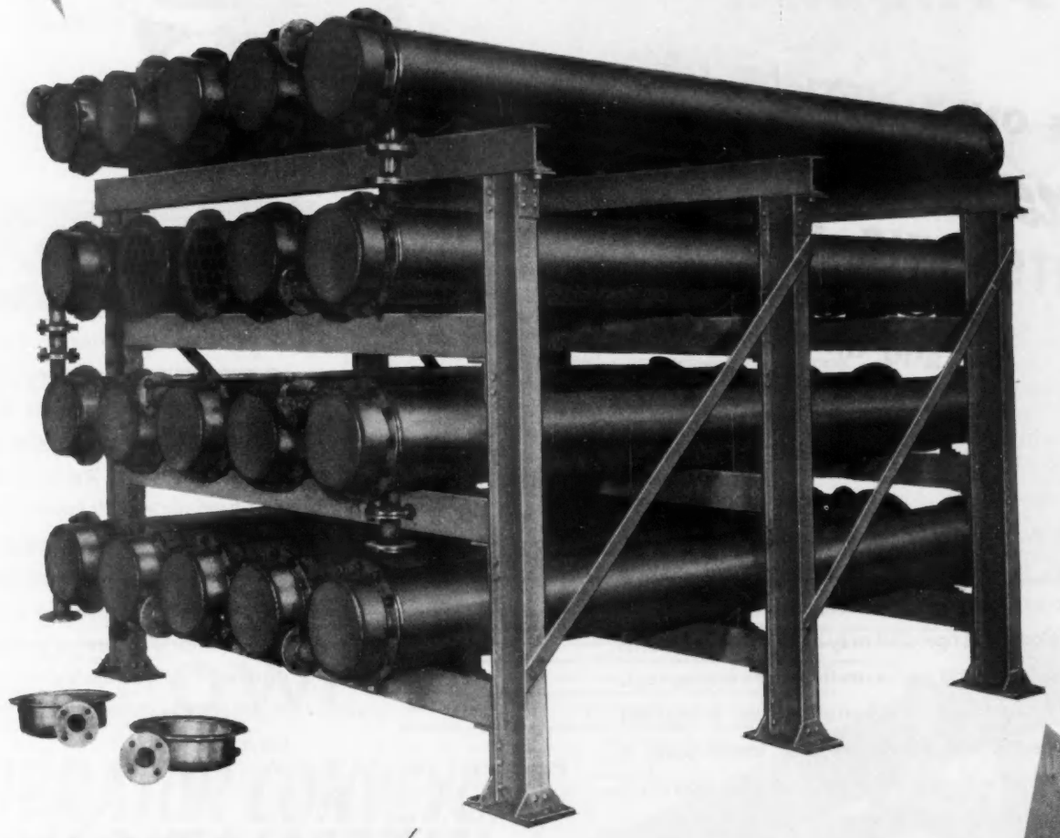

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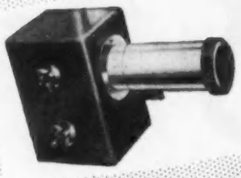

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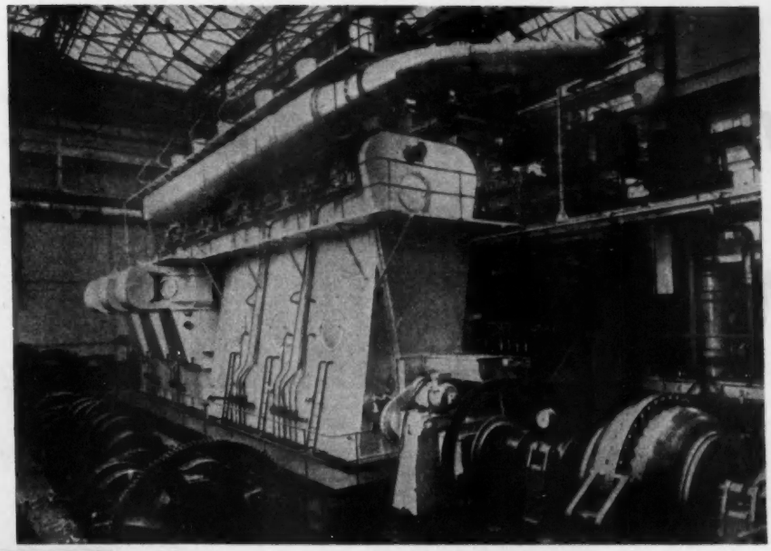

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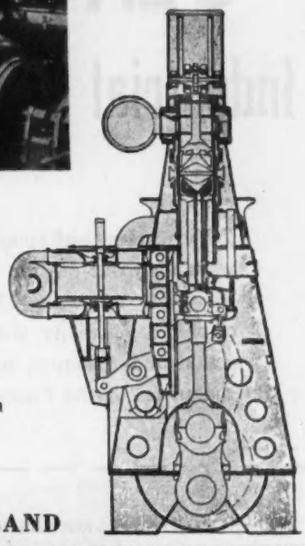

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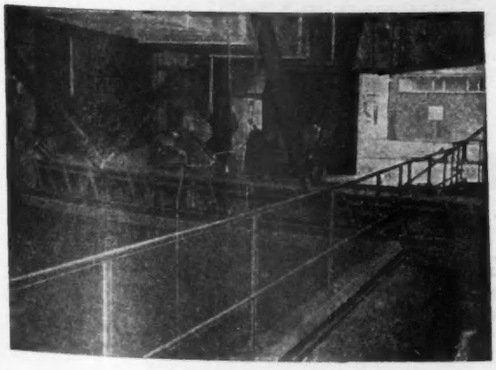

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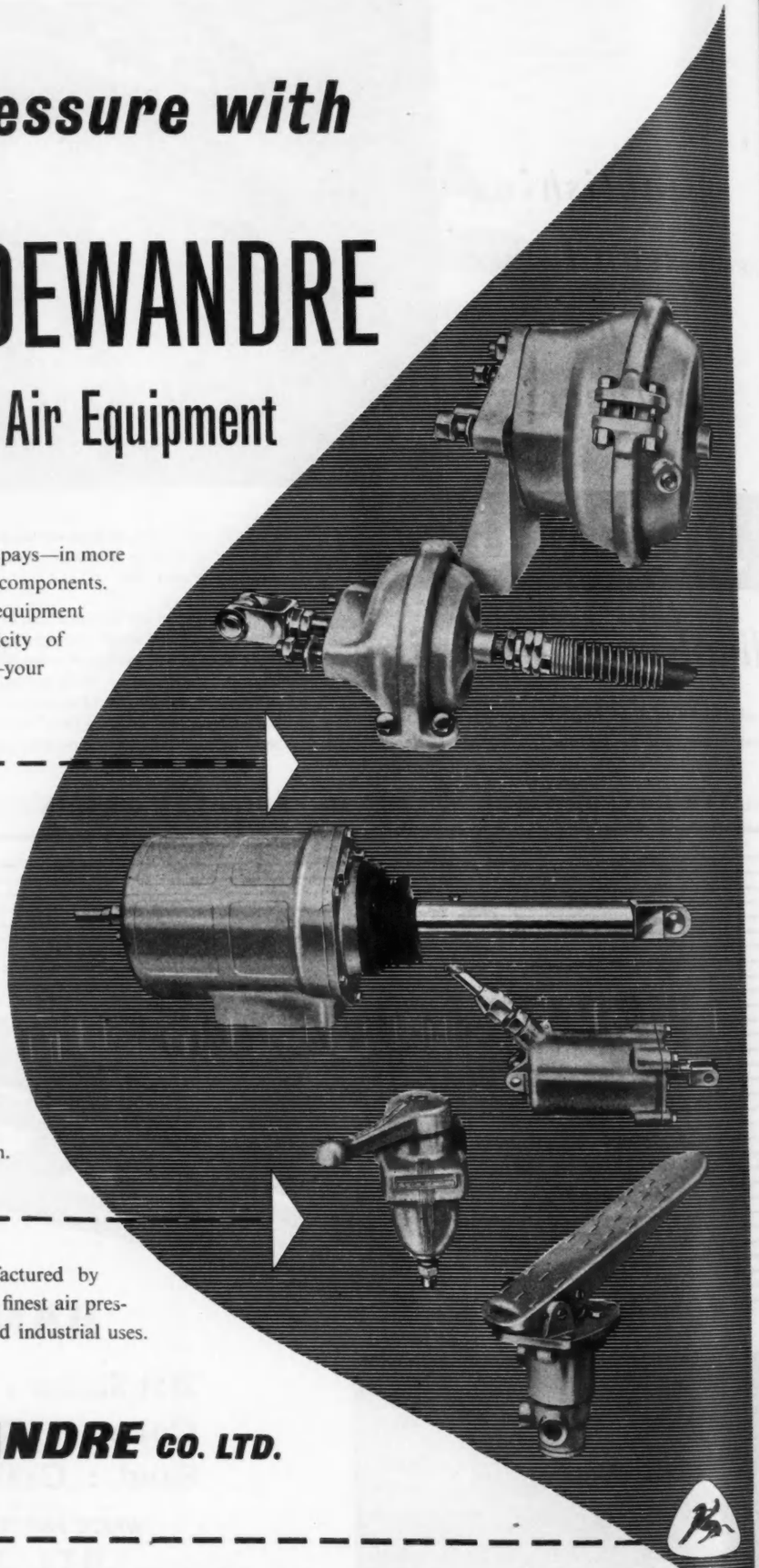

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AP31

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AND
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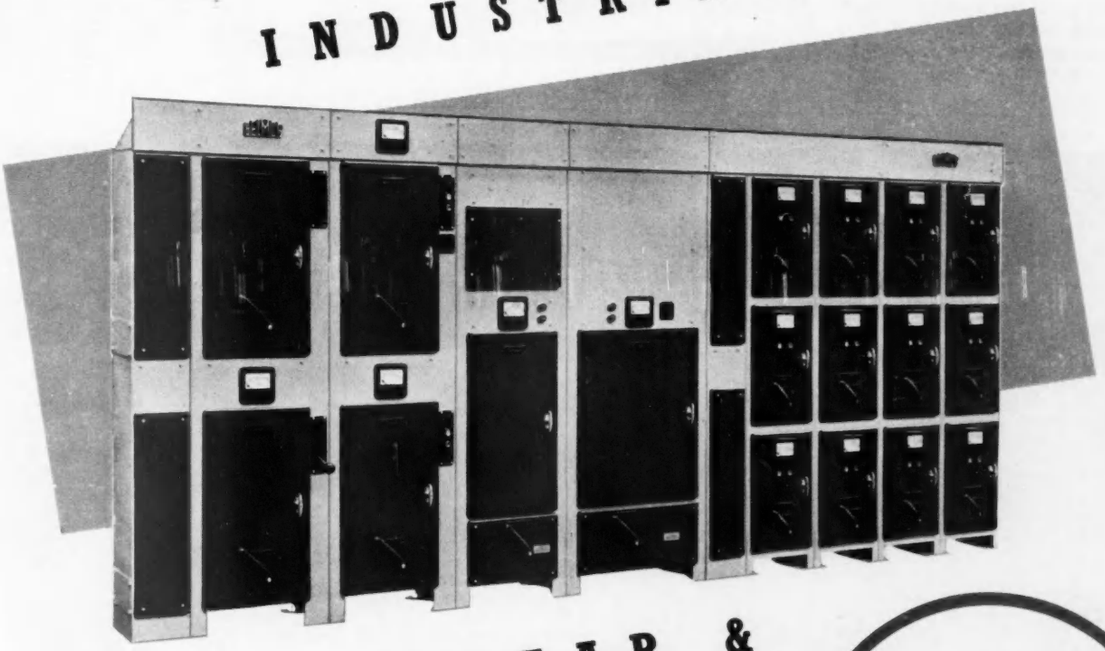

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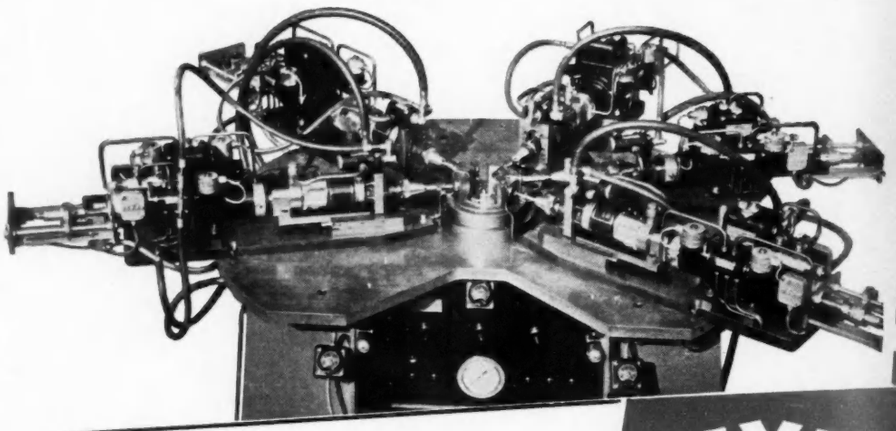

and for your job too—

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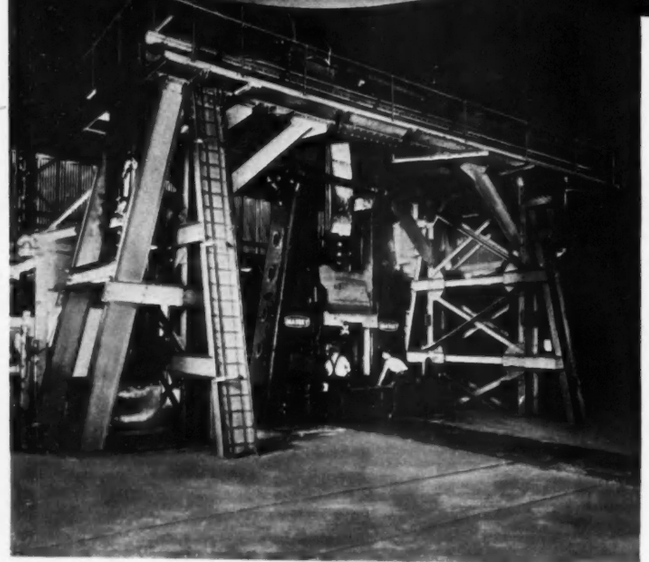

Photographs by courtesy of Messrs. Smith-Clayton Forge Ltd., Lincoln

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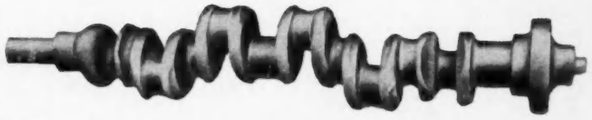

In the manufacture of engines for heavy road transport vehicles MASSEY Forging Plant is used for the production of high precision forgings. The photograph shows a large MASSEY Bridge Type Drop Hammer producing engine crankshaft forgings at Messrs. Smith-Clayton Forge Ltd., Lincoln. These MASSEY Drop Hammers are made in a range of sizes from 10 cwt. to 16 tons capacity, and produce forgings of the most intricate type at high production speeds. Their ease of control and adaptability, added to considerable economy in running and upkeep costs, make them essential in any general forge.
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The extracts quoted are from a letter written by E. Loades, Esq., Managing Director of The Abbey Panel & Sheet Metal Co. Ltd., Coventry and Bedworth.

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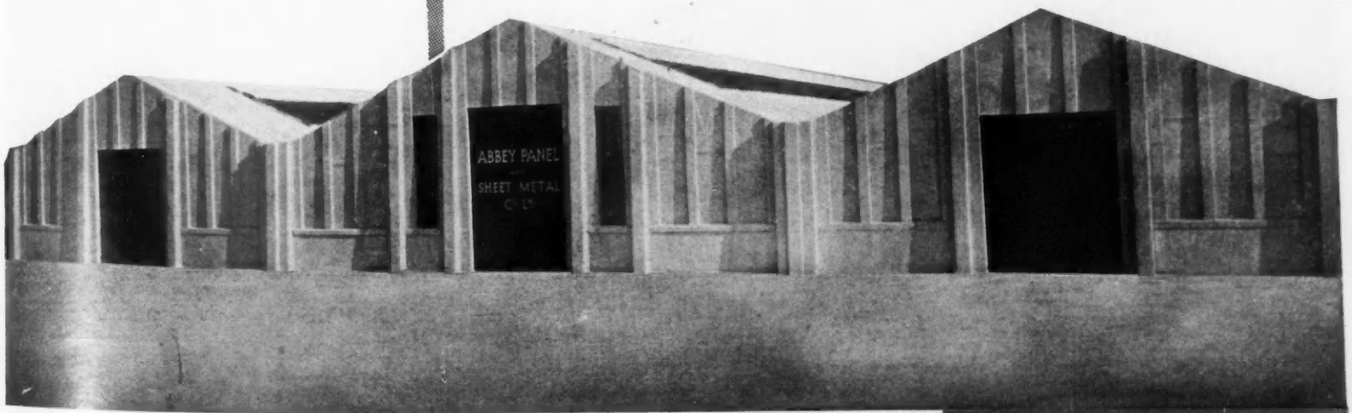

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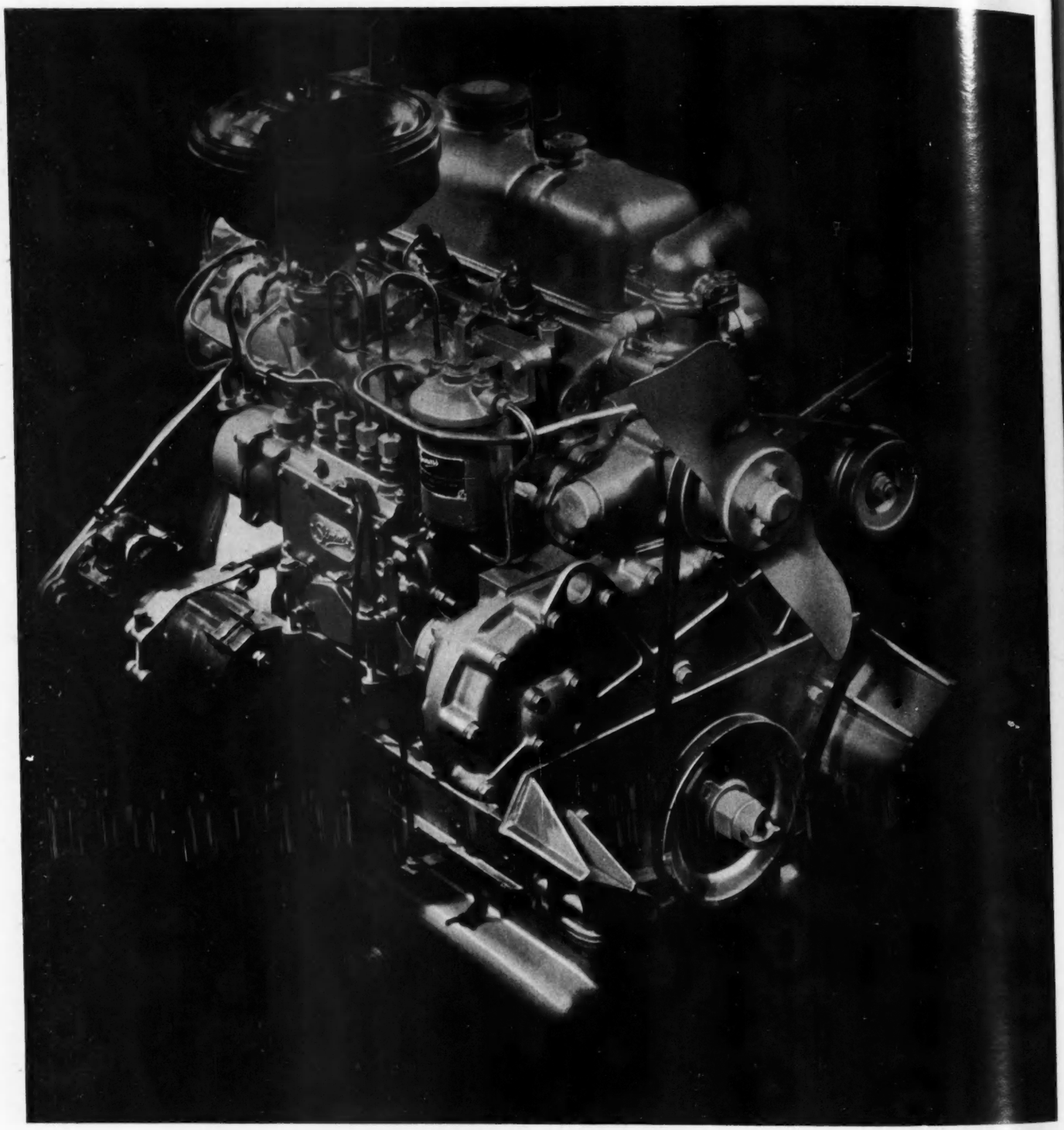
AP. 211/58



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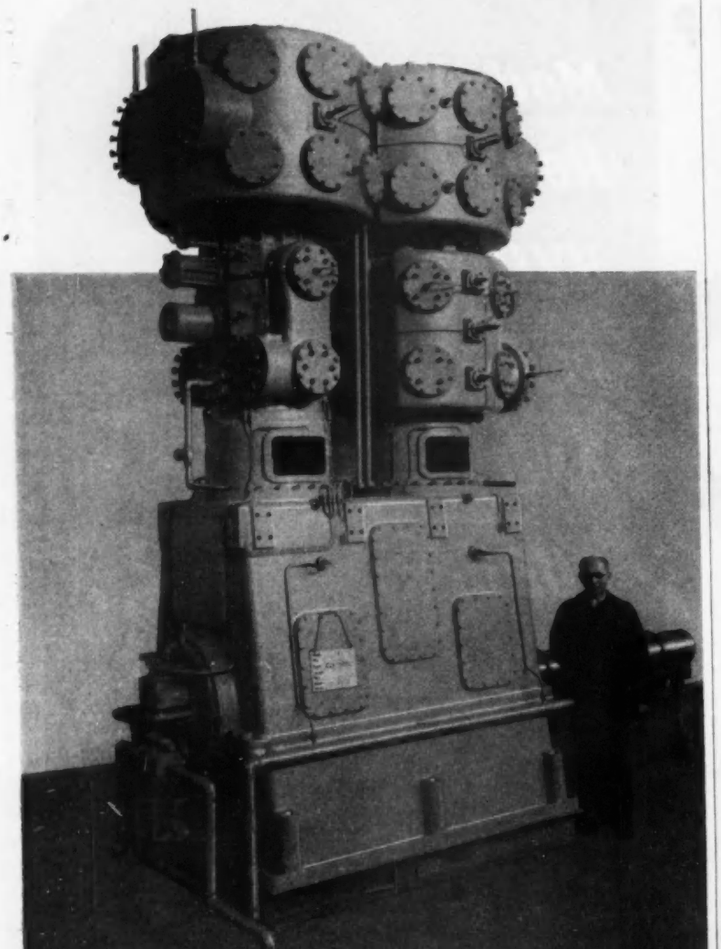

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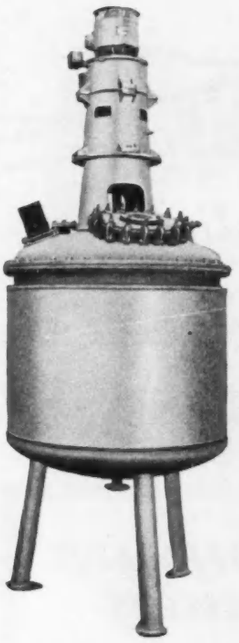

M.S. Jacketted Mixer with Vertical Geared Motor driving Anchor type Mixing Paddles. Vessel fitted with Inspection Lamp, Sight Glasses, and quick release Charging Door.

Pressure Vessel with quick release facilities for domed top. Test Press : 200 lbs. /□"

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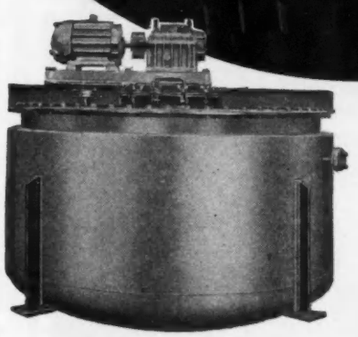

535 Galls. Capacity Jacketted Mixing Vessel. Agitating gear driven by foot mounting Motor through T.E. Reduction Gear. Vessel tin-coated on internal surfaces.

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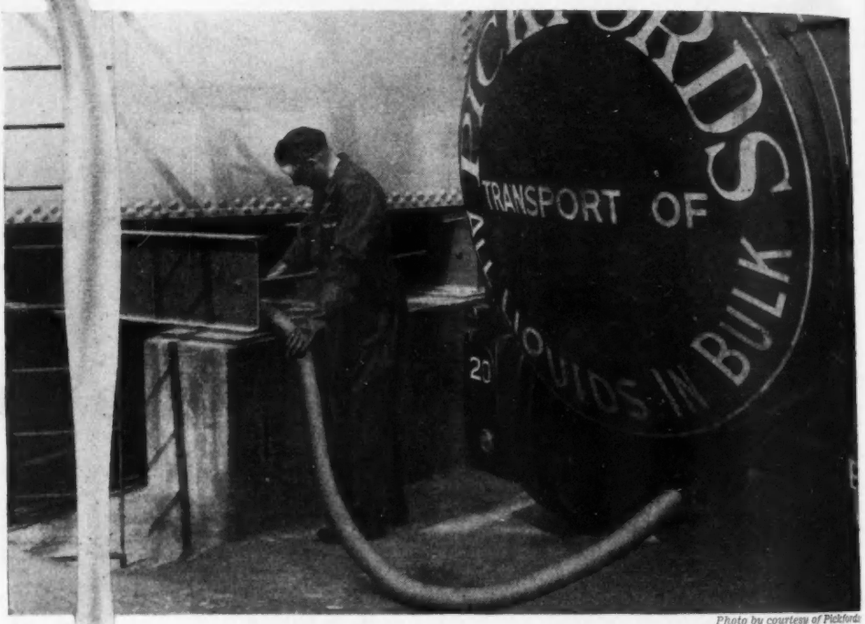

Photo by courtesy of Pickfords

A 'FLEXIBLE' PROBLEM—a Compoflex answer. When Pickfords needed a flexible hose to carry sulphuric acid in concentration of up to 94% they consulted Compoflex. The hose supplied has now been in use for six months, yet despite high working pressures and temperatures, and severe flexing, it showed no sign of internal or external wear when tested. This new Compoflex flexible had stainless steel helix with a liner of Molene-coated glass cloth, plies of Polythene sheeting, a layer of glass cloth, an outer of abrasion and acid-resistant p.v.c., and a spiral of mild steel wire.

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• if there is a 'flexible' answer, you'll find it at

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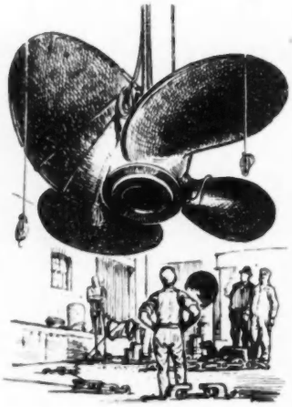
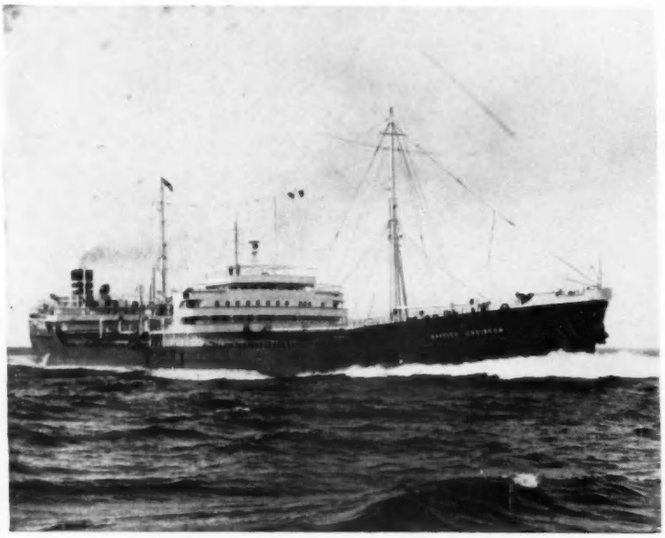
AP 323-10

COPPER

makes a good job better



Over a thousand tons of copper may be used in a large ocean-going vessel. Propellers, condenser tubes and distillation plant are almost invariably made of copper alloys to resist salt-water corrosion. Miles of copper tube and wire are used in the plumbing and electrical installations, while copper alloy tubes are often used for heating the oil in tankers. Large quantities of brass and gun-metal are used for port-holes, doors, voice-pipes and countless other deck and cabin fittings. The hull is protected from marine organisms by anti-fouling paints containing copper.



Not only in shipbuilding, but in most major industries, copper and its alloys play a vital part. The purpose of the Copper Development Association — a non-trading organisation — is to advise on the best uses of copper and its alloys. Its services are always available without charge or obligation.

COPPER DEVELOPMENT ASSOCIATION

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TGA 057

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The electric eye of the Reflectometer tests the grading with the utmost precision. First, the pencil is inserted into a Shading machine which moves the paper back and forth beneath the point. The resulting chart is placed under the electric eye of Reflectometer calibrated to black and white glass standards, and the dial records the blackness to a fraction of one per cent.

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with 100% 'ELECTRONIC' Graphite

T7

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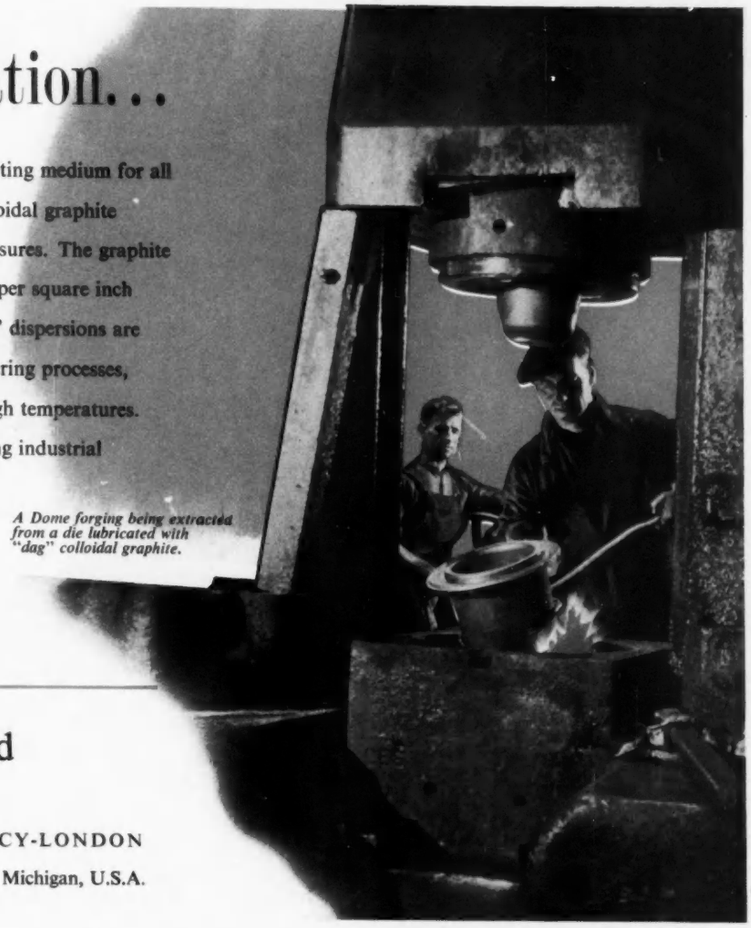
"dag" colloidal graphite is the perfect lubricant and parting medium for all metal-forming operations. Dies treated with "dag" colloidal graphite offer maximum resistance to high temperatures and pressures. The graphite coating is capable of withstanding loads of several tons per square inch and greatly improves slip between metal and die. "dag" dispersions are equally effective for casting, extrusion and other engineering processes, and for the lubrication of all equipment operating at high temperatures. The benefits of our 40 years' experience in manufacturing industrial dispersions are freely at your disposal.



A Dome forging being extracted from a die lubricated with "dag" colloidal graphite.

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For full particulars, write for a copy of publication SEB.89A in which will be found a questionnaire for completion and return to us.

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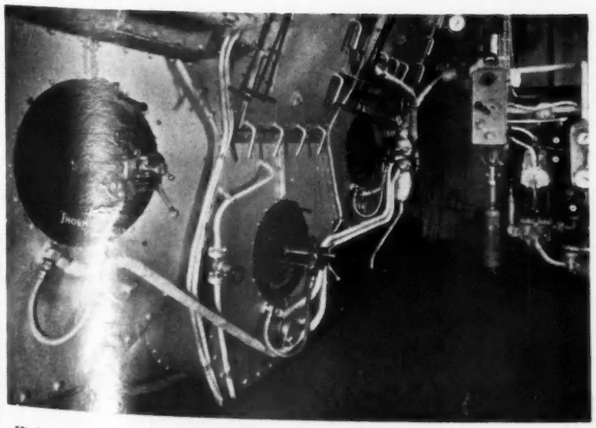
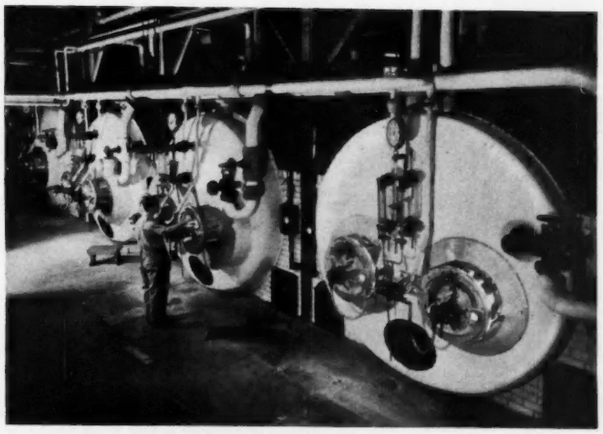
FOR MARINE AND INDUSTRIAL PURPOSES

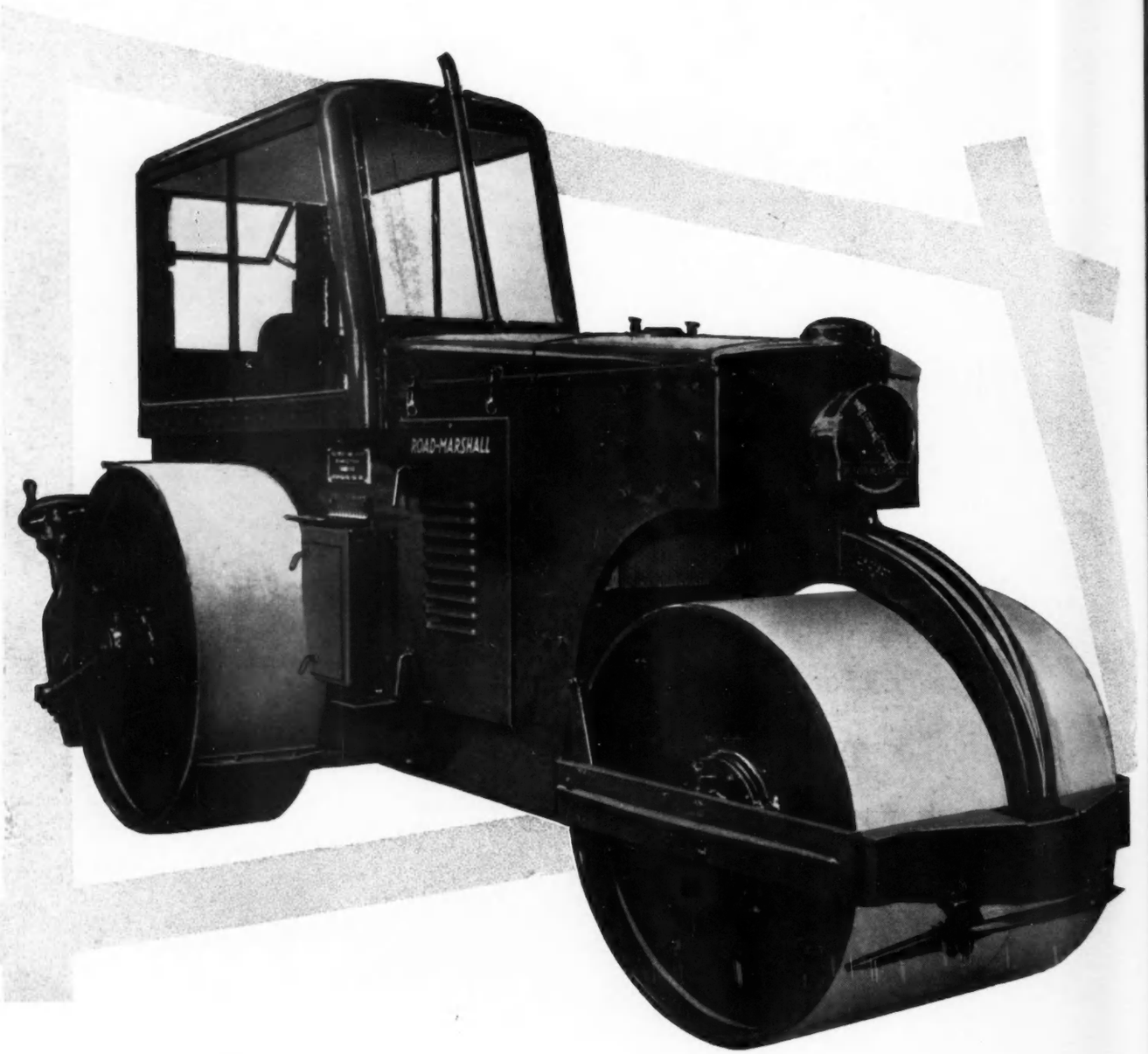


High pressure oil fuel installation in the tug "Horus" built by us for the Suez Canal Company.



Part of the installation at Messrs. Courage's Alton Brewery.

JOHN I. THORNYCROFT & CO. LIMITED, WOOLSTON WORKS, SOUTHAMPTON



The New "Six-Eight" Road-Marshall

The ROAD-MARSHALL Series "SIX-EIGHT" is a new medium weight Roller which has been produced in response to repeated enquiries from our customers. We know that many users of the heavier ROAD-MARSHALL Diesel Rollers wished to have a medium weight Marshall roller as well, but up to now this has not been available.

There are two sizes giving weights 6-9 tons and 7-10 tons. The usual wide range of extra equipment can be fitted to suit Customers' specifications.

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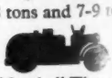

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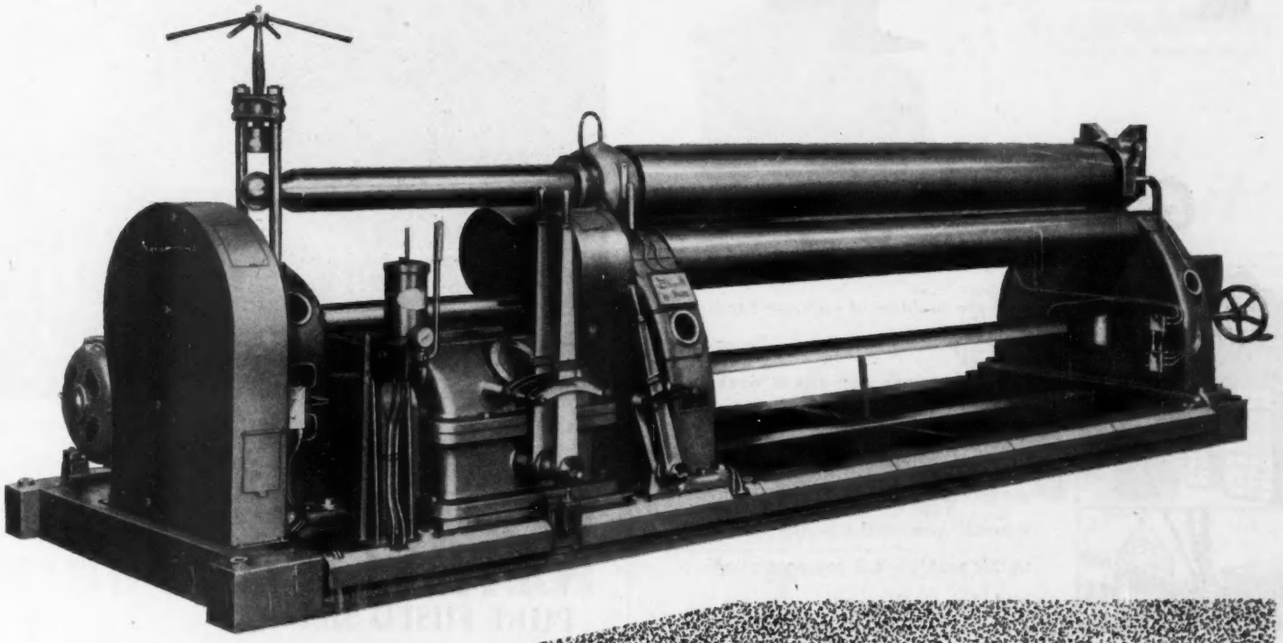

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B.131

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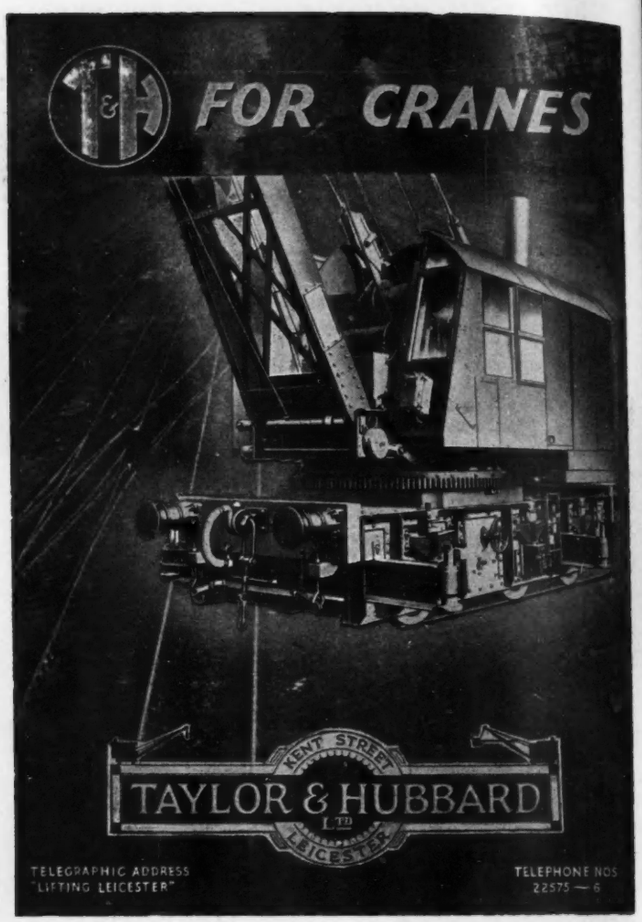

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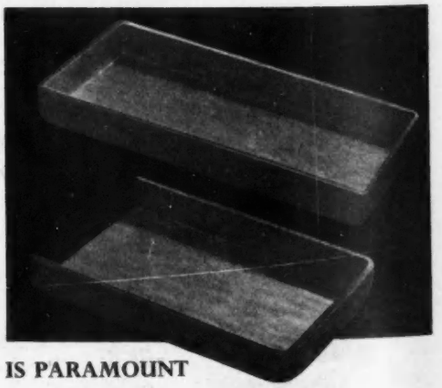

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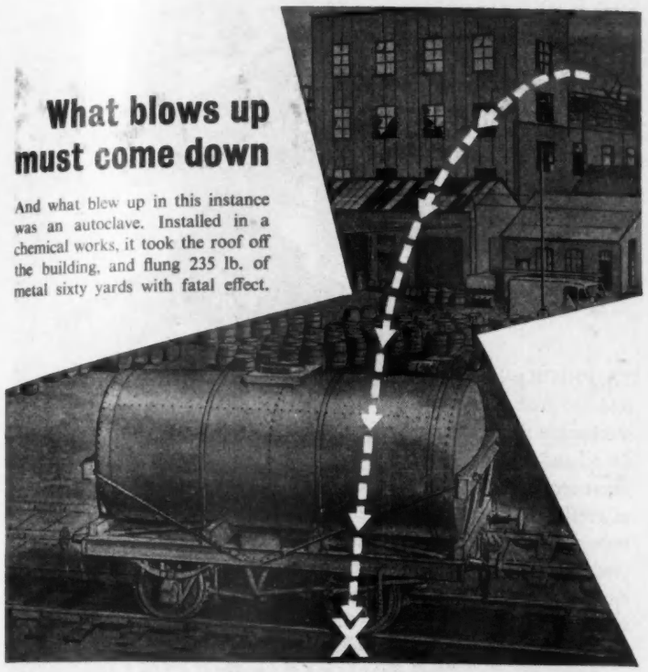

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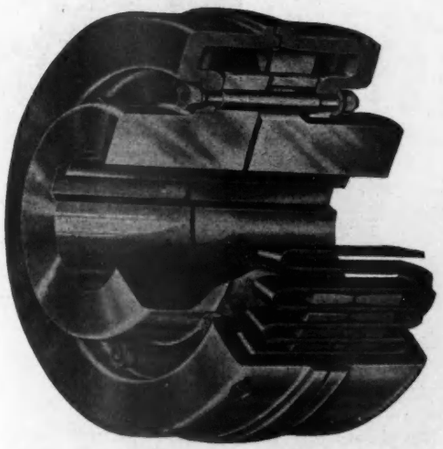

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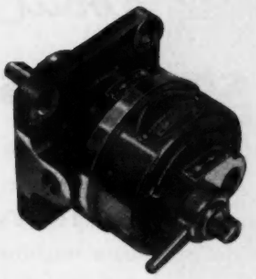

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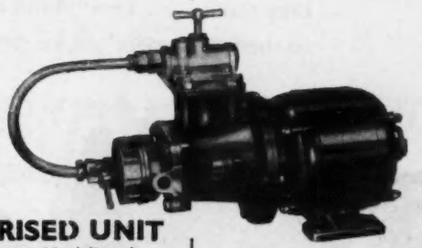

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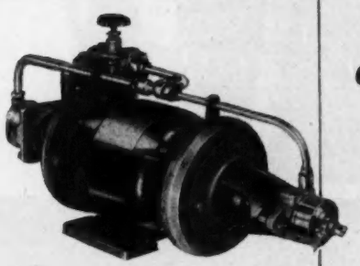

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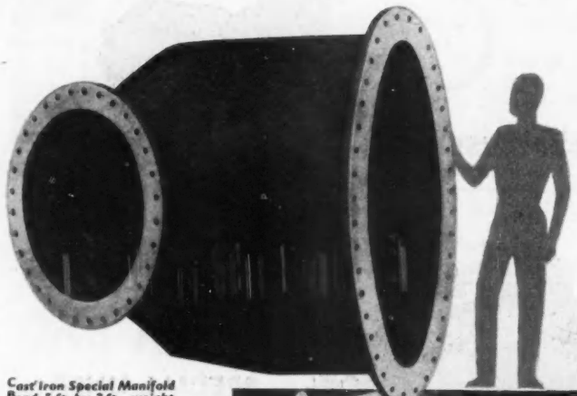
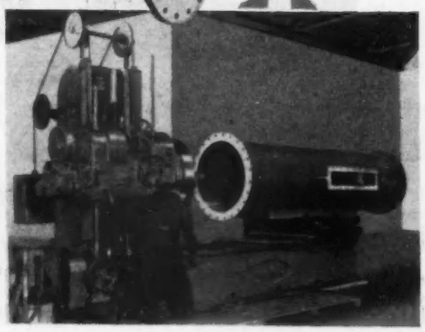


Cast iron Special Manifold Bend 5 ft. by 3 ft., weight 2½ tons.



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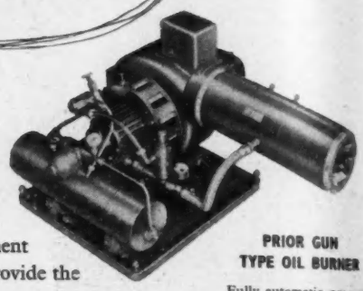

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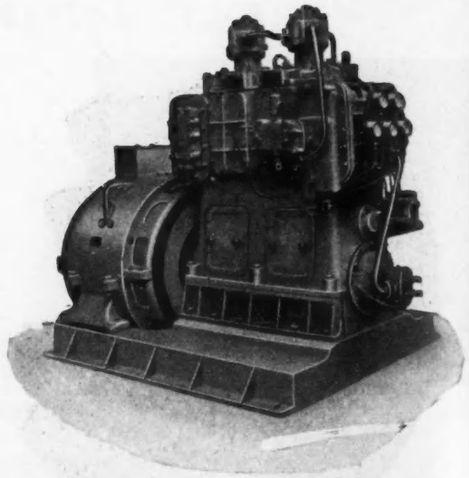

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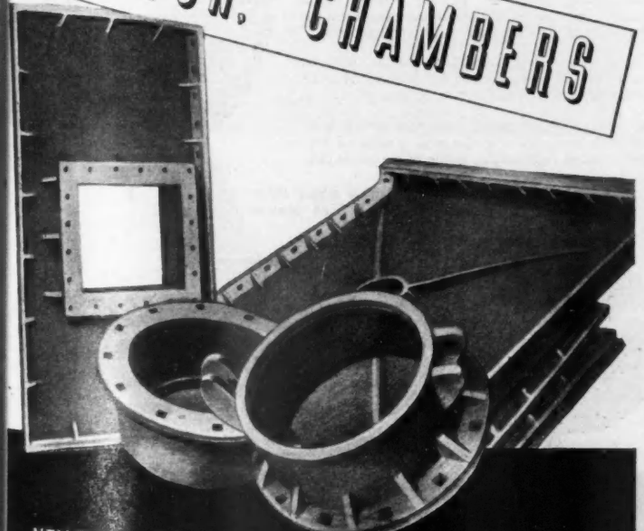

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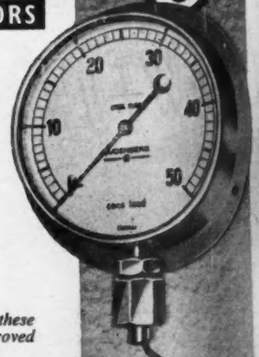

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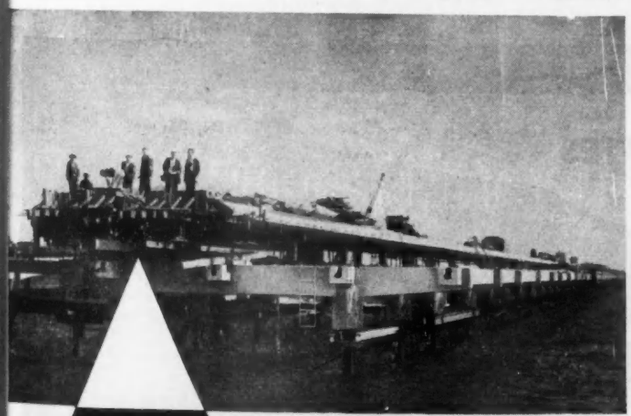

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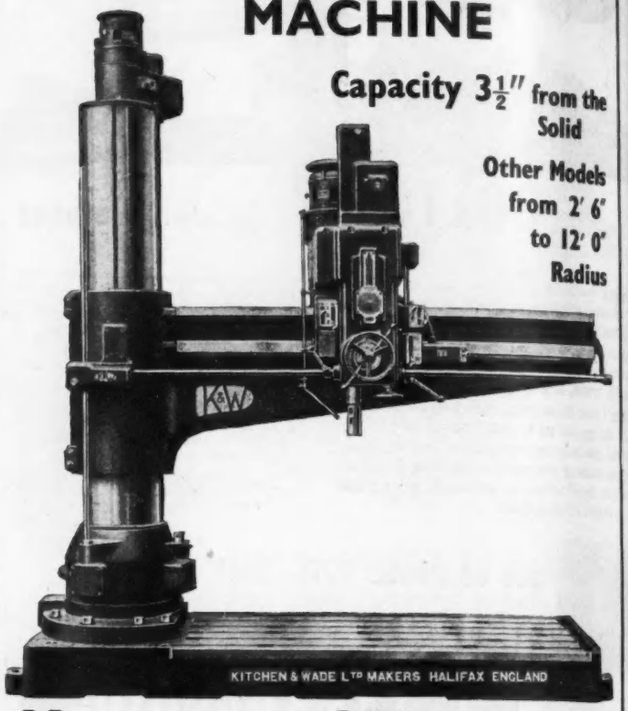

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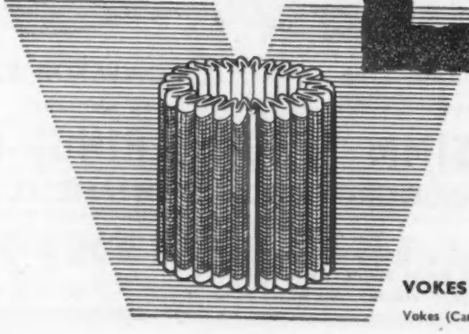

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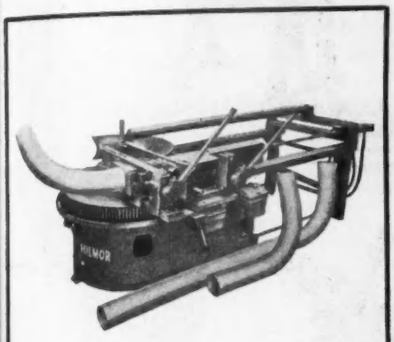

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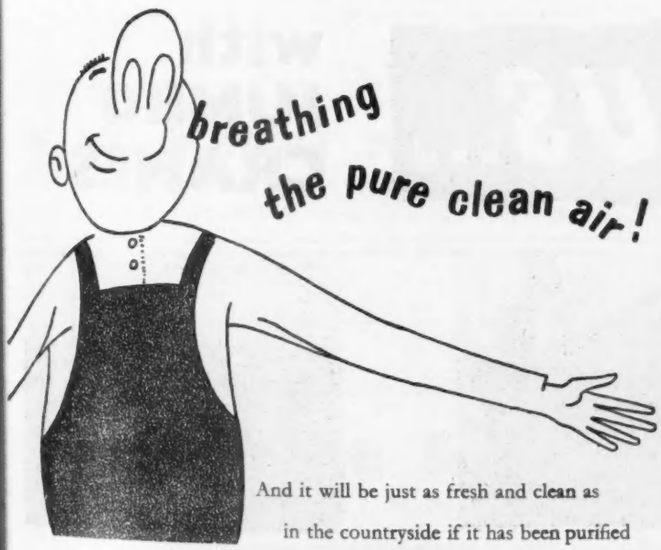

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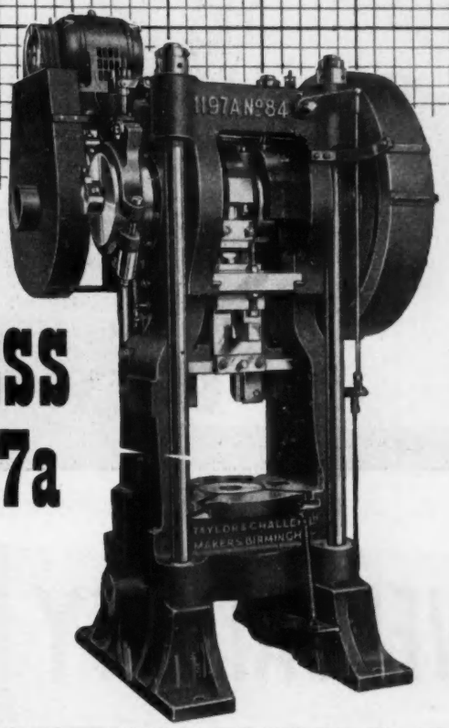
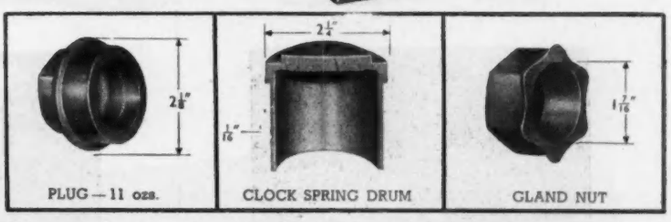


PRESS 1197a



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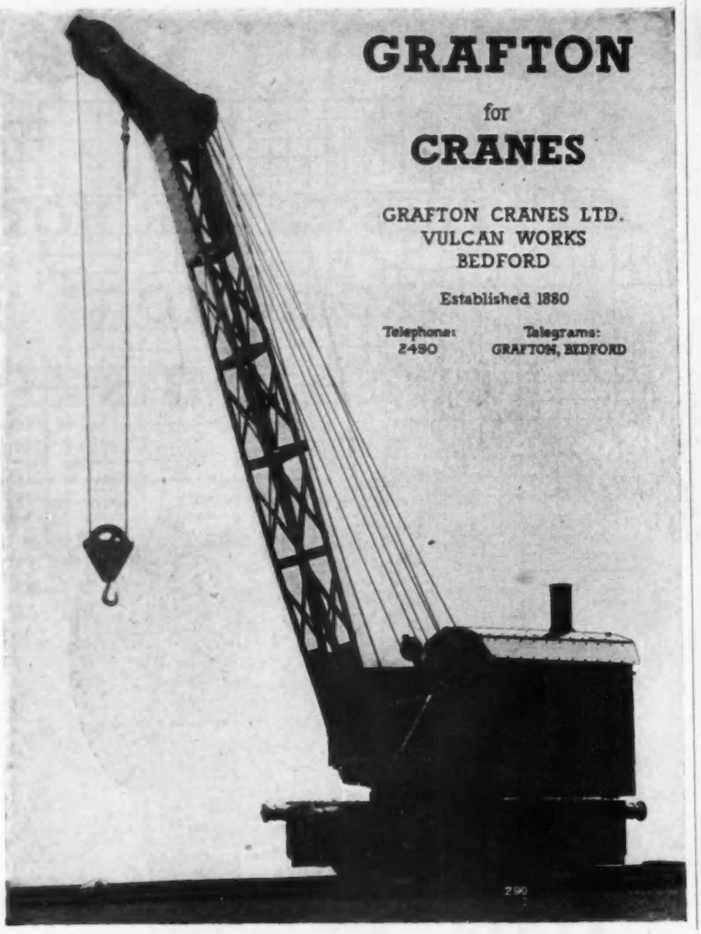

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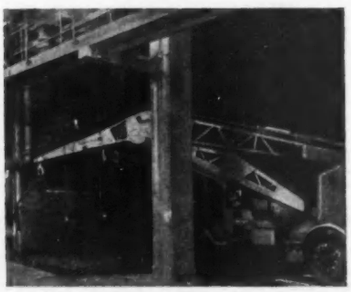
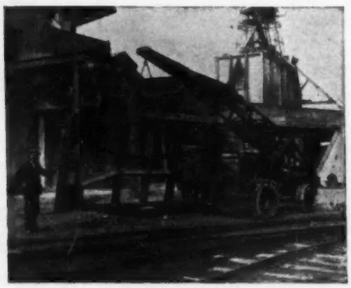
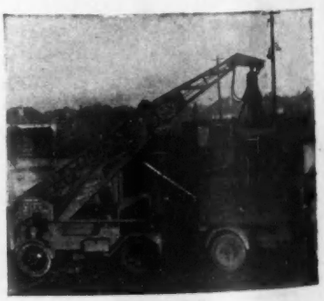


The 4-ton Jumbo Crane lifting a skip of ashes in the 25 cwt. position at Fulham Power Station. Headroom is only 11ft. 2in., so the jib extension, and not the main jib, is being used with unimpaired efficiency.



The Jumbo Junior lifting a railway truck chassis weighing approximately 30 cwt. at Associated Portland Cement Manufacturers, Greenhithe.



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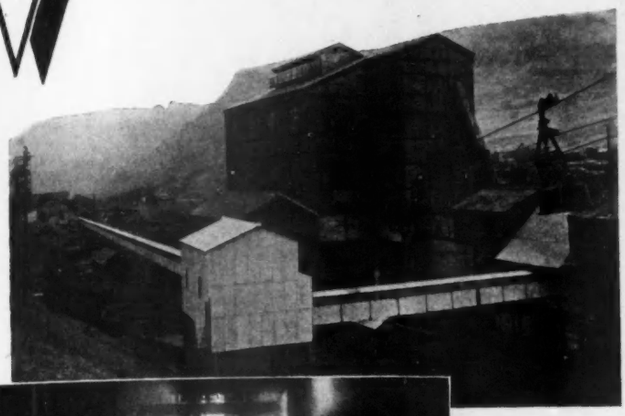

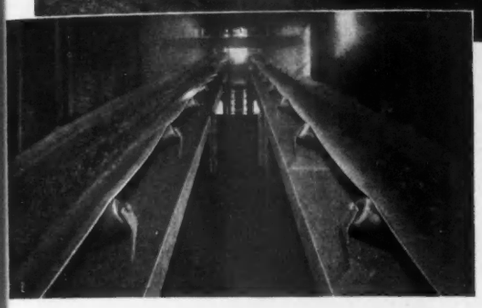

(Above) Troughed Belt Conveyor Gantries and Corner Transfer House at Fernhill Colliery, South Wales.

(Left) Twin Troughed Rubber Belt Conveyors feeding small Coal and Rubbish to Washery & Bucket Elevators at South Celynen Colliery, South Wales.

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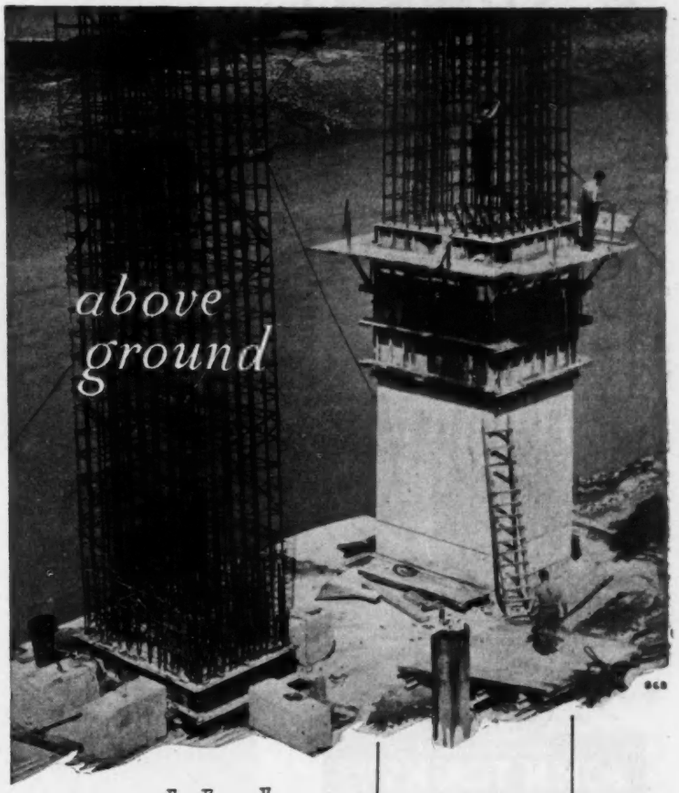

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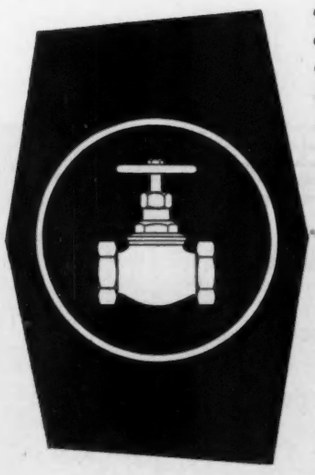

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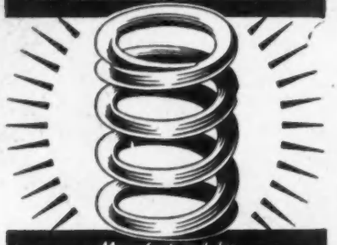

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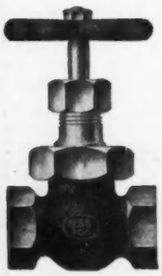

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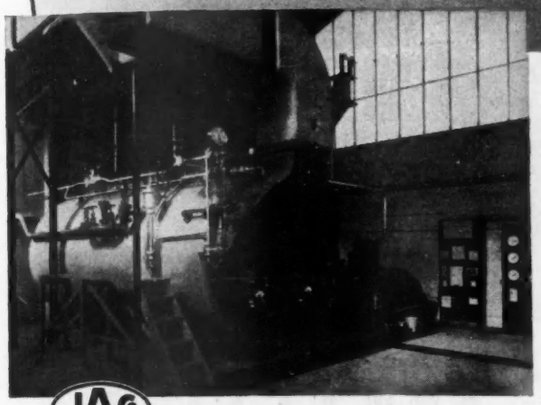

The new, revised edition of our booklet "The Choice of a Boiler" gives a concise summary of various types of shell boiler, and will be sent to responsible engineers, etc., writing on firms' letter headings.

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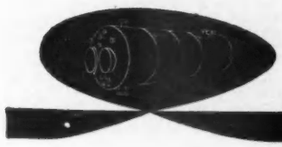

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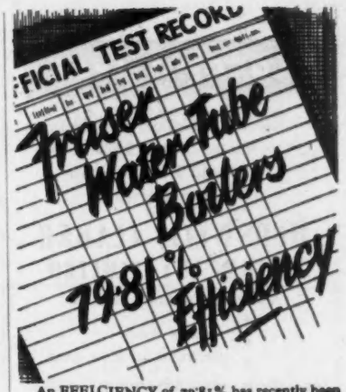

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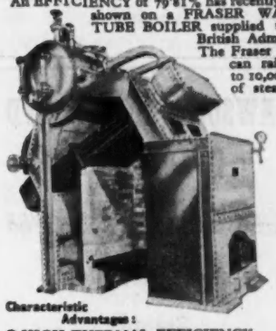

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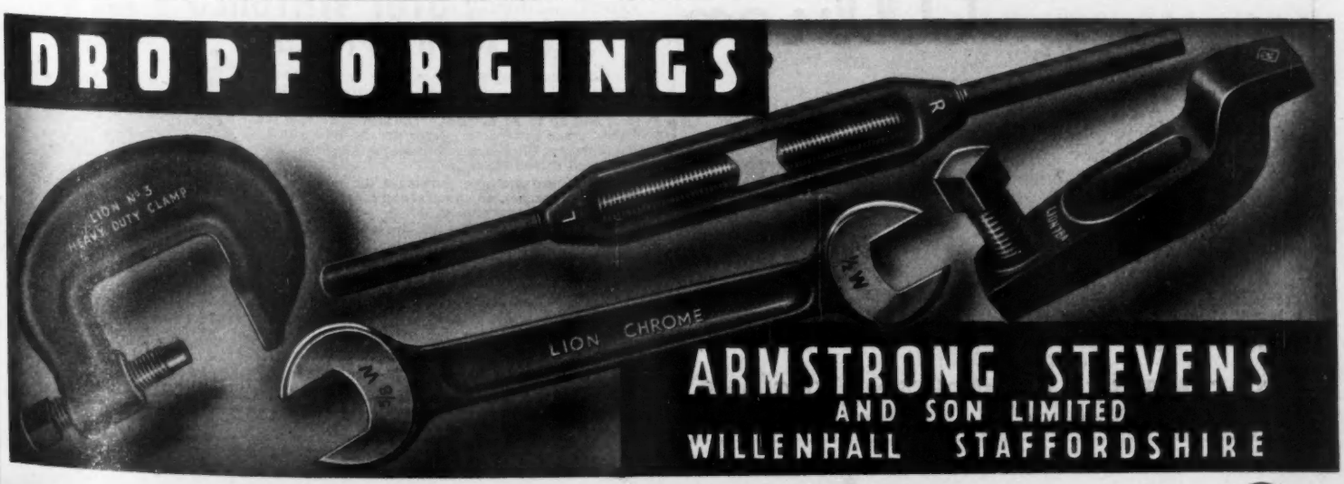

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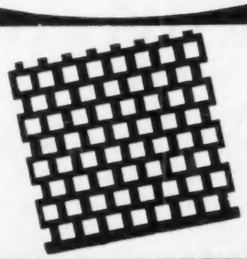

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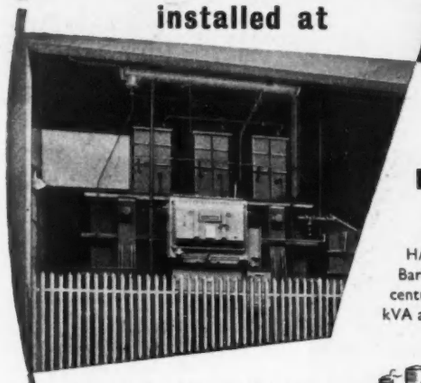

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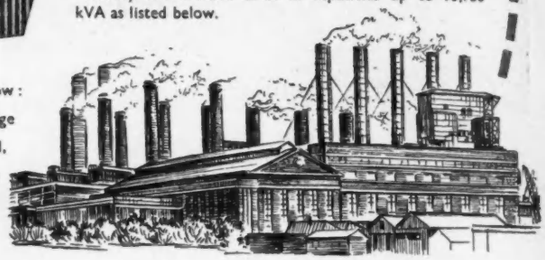
The installations illustrated show: above, one of the four Hackbridge 93,750 kVA transformers, and, below, one of the three 88,750 kVA Units at Barking Power Station, London.



Four 93,750 kVA	Two 12,500 kVA	Four 600 kVA
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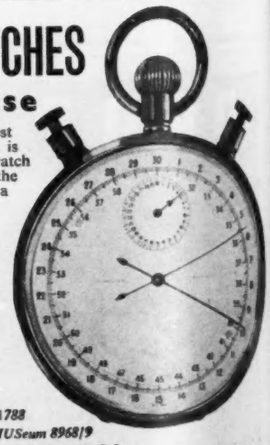

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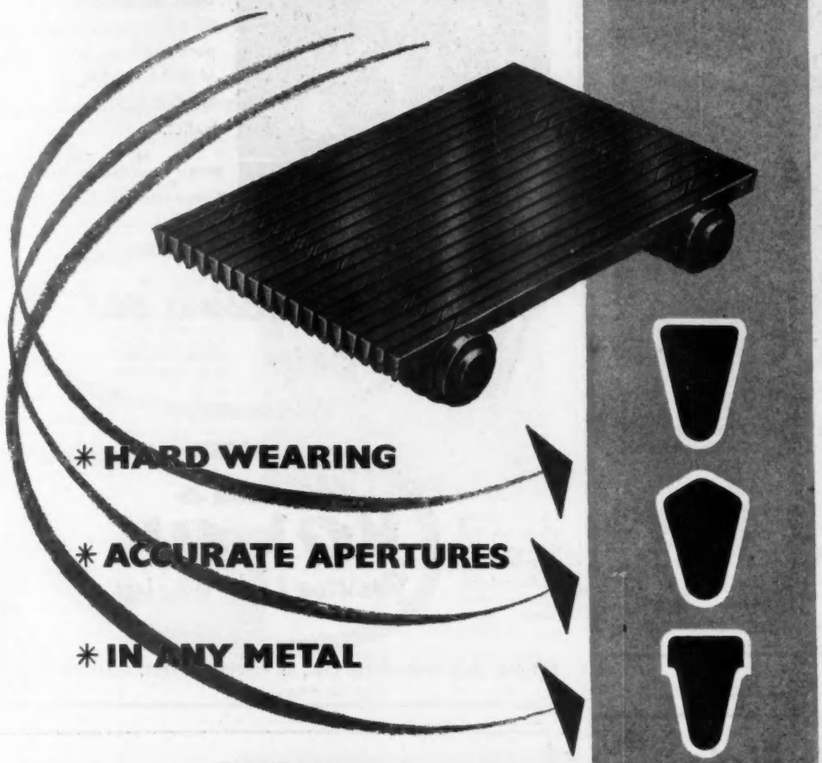

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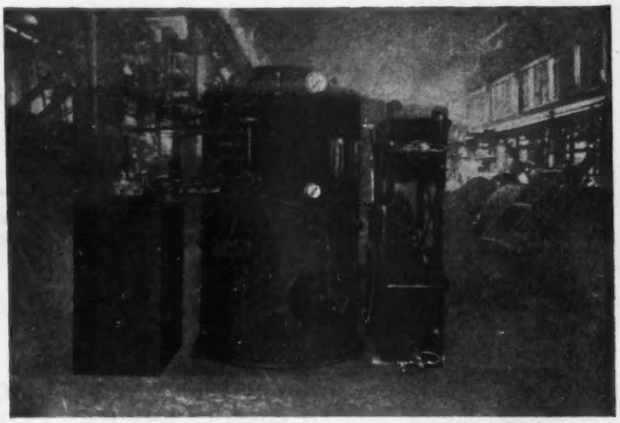

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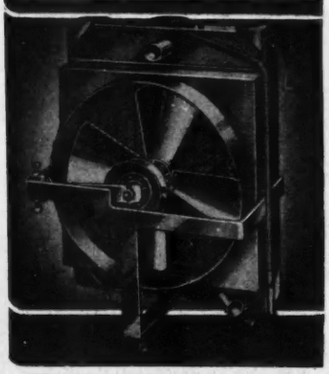

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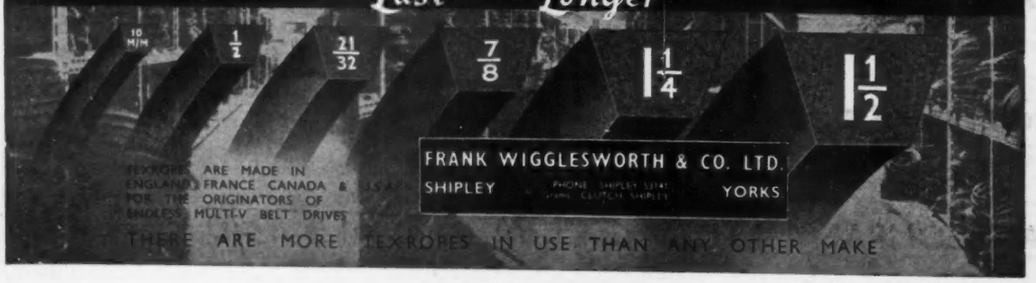

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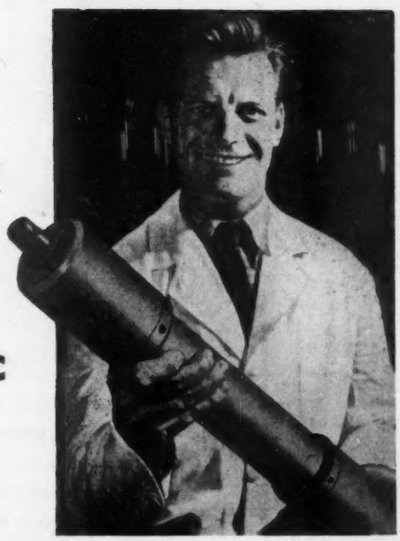

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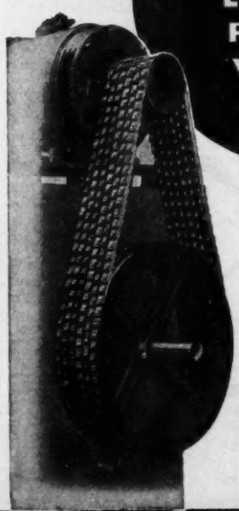

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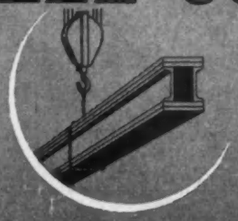

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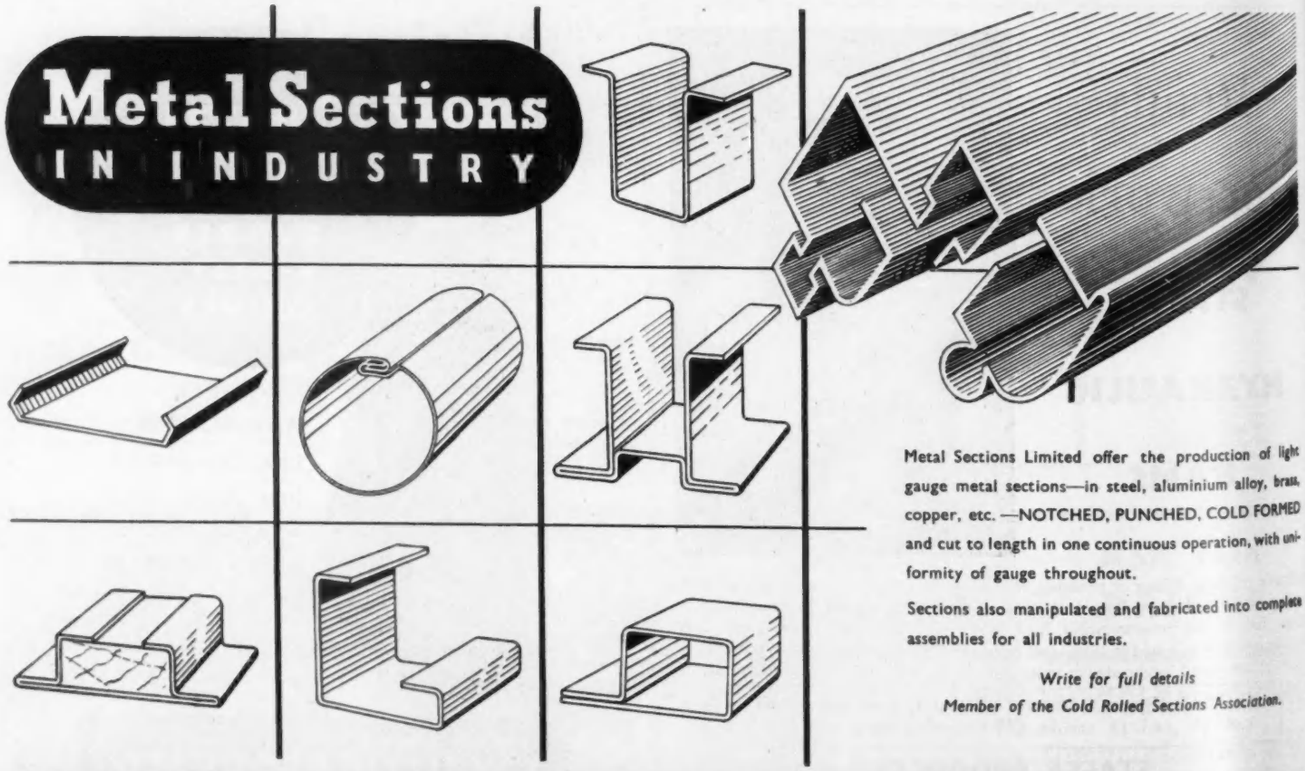

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BAROMETRIC AND LOW LEVEL TYPES
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Classified Advertisements continued from Page 8

Applications are invited for the position of **BUYER** responsible to the Commercial Manager in old-established factory in Lune Valley district of Lancashire. Sound references and previous experience are required including ability to improve system of purchasing schedule, stores control and requisitioning of considerable variety of textile, plastic and chemical materials. The position is a permanent one, superannuable, and offers a most attractive opportunity to a man aged 28-35 of the right character and capability. Assistance with housing can be given if necessary.—BOX L 534, Offices of ENGINEERING.

SENIOR DRAUGHTSMAN wanted for makers of Machine Tools and Sheet Metal Machines. Non-contributory Insurance and Pension Scheme. Age, experience, salary, etc., to F. J. EDWARDS, LTD., 359, EUSTON ROAD, LONDON, N.W.1. L 501

THE G.E.C. STANMORE LABORATORIES require
ENGINEERS WITH H.N.C. OR DEGREE, with some knowledge of aircraft electrical work and preferably some experience of airborne equipment for planning the installation of radar equipment in aircraft. Applicants without the necessary academic qualifications but with considerable experience of this type of work will receive serious consideration.—Please apply, in writing, to the STAFF MANAGER, G.E.C. STANMORE LABORATORIES, THE GROVE, STANMORE, MIDDX., quoting ref. E/JT. L 485

DESIGNER, B.SC. ENG., for Scientific Instrument and Laboratory apparatus works at Mitcham, Surrey. Age 25-30. Range wide in interest and variety.—Write details experience and salary required to TECHNICAL DIRECTOR, GRIFFIN & GEORGE, LTD., EALING ROAD, ALPERTON, WEMBLEY, MIDDX. L 525

BRITISH THOMSON-HOUSTON CO., LTD.
There are vacancies in the Valve Engineering Department for work connected with the engineering and development of semi-conductor devices. Those with qualifications (H.N.C. and above) in electrical engineering or physics are wanted for development projects involving transistors and rectifiers; an interest in radio would be an advantage. Qualified Mechanical Engineers (H.N.C. and above) are needed to design and develop jigs and automatic machines for device manufacture.
Applicants are invited to write to the HEAD OF THE VALVE ENGINEERING DEPARTMENT, BRITISH THOMSON-HOUSTON CO., LTD., LADYWOOD WORKS, LUTTERWORTH, NR. RUGBY, giving details of their age, qualifications and experience. L 573

DRAUGHTSMAN required for Engineering Department of modern Tar Distillery. Applicants should be of at least O.N.C. Standard with General Engineering experience, preferably including plant layout and piping. Varied and interesting work, including some site work. Pension scheme. Salary up to £750 per year. Interviews may be arranged on Saturday mornings if desired.—Apply to CHIEF ENGINEER, LANCASHIRE TAR DISTILLERS, LTD., LIVERPOOL ROAD, CADISHEAD, NR. MANCHESTER. Tel.: Irlam 2001. L 496

JOHN BOOTH & SONS (BOLTON), LTD., invite applications for the position of
MANAGER for their Branch Works in Bolton. Candidates should have had experience in the manufacture of Steel Doors and Steel Rolling Shutters, and should write stating age and experience to THE DIRECTORS, JOHN BOOTH & SONS (BOLTON), LTD., HULTON STEELWORKS, BOLTON. L 498

QUALIFIED ENGINEER required by Rubber Manufacturer who is extending his range of manufacturing interests. The successful applicant will lead a development team investigating the techniques involved in the manufacture of new products.
Minimum qualifications are B.Sc. (Hons.) degree and/or Associate Membership of the Institution of Mechanical Engineers. It would be preferable if applicants had some knowledge of the Rubber or Plastics Industry.
This is a Senior Company appointment and will carry a salary commensurate with ability and achievements. An excellent opportunity for a young practical engineer of energetic and inventive disposition.—BOX L 491, Offices of ENGINEERING.

A large Industrial Organisation has a vacancy for a **QUALIFIED MECHANICAL ENGINEER,** aged 30-35, with good social and educational background, to train as a specialist, finally to take charge of staff probably situated in the Yorkshire area.—Reply, stating full details of age, qualifications and experience to BOX L 506, Offices of ENGINEERING.

SENIOR DRAUGHTSMEN with H.N.C. Mech. for Plant Development Work. Experience of Cable Machinery advantage. Good prospects and special pay for right men. Pension Fund and Bonus Scheme.—Apply STAFF OFFICER, B.I.C.C. LTD., BELVEDERE, KENT. L 552

Classified Advertisements continued on Page 116

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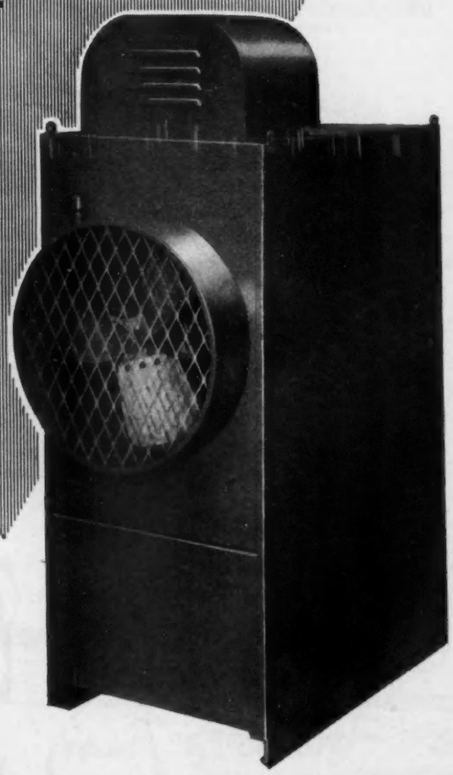

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MECHANICAL ENGINEERING DRAUGHTSMEN. Applicants should be experienced in Plant Layout work preferably, but not essentially in connection with Steam Power Stations. Salaries will be fully appropriate to Applicants' experience, rising from about £740 per annum at age 25. Excellent working conditions. Five-day week. Pension Scheme. Canteen.—Apply in writing to MERZ AND McLELLAN, MILBURN, ESHER, SURREY. L 515

CHIEF DRAUGHTSMAN required for general mechanical engineers, North London district. Only those with previous experience of drawing office control or at least section of 10 draughtsmen should apply.—Write giving full details of past experience and indication of salary to BOX L 566, Offices of ENGINEERING.

CIVIL ENGINEERING ASSISTANTS required for Extensive Developments at a modern Iron and Steel Works in the Midlands. Applicants should have experience in design of mass foundations, reinforced concrete and civil engineering work generally. Favourable Housing prospects. Applicants should give details of experience and of salary required.—Apply to BOX L 569, Offices of ENGINEERING.

SKILLED PLANNING ENGINEERS.
The above are required by a large Engineering firm (Newcastle upon Tyne). Applicants must be experienced in general engineering, modern machine tooling methods and job production. Give fullest details of age, experience, etc.—Write BOX L 513, Offices of ENGINEERING.

CIVIL ENGINEERING DESIGNER/DRAUGHTSMEN are required for Extensive Developments at a large Iron and Steel Works in the Midlands. Applicants should have experience in civil engineering design. Housing prospects are favourable. Applicants should give details of experience and of salary required.—Apply to BOX L 570, Offices of ENGINEERING.

One or more
ASSISTANT CIVIL ENGINEERS required for important development work in heavy industry. Ability to take complete control of sections of work essential. Please state experience and salary requirements.—Apply to BOX L 571, Offices of ENGINEERING.

ESTIMATING ENGINEERS required by Humphreys & Glasgow, Ltd. Must have experience in estimating for general or chemical engineering projects. Permanent and superannuated post carrying a good salary. Five-day week. Holiday arrangements respected.—Apply in writing to HUMPHREYS & GLASGOW, LTD., 22, CARLISLE PLACE, LONDON, S.W.1. L 505

CHIEF ESTIMATOR AND CONTRACTS ENGINEER required for Engineering firm in East Midlands. Experienced in some or all of the following branches of Engineering:
Structural Steelwork—shop and sitework.
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Colliery Circuit Reorganisations.
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Concrete Footings.
Salary £900 to £1,000 per annum according to experience and age.
Pension Scheme. Canteen.
Apply giving details of experience, education, age, etc., to CHIEF ENGINEER, BOX L 510, Offices of ENGINEERING.

SHELL REFINING & MARKETING CO., LTD.,
invite applications for the following vacancies in the Purchasing Department of their London office.
(A) **BUYER** with experience in large scale purchasing of heavy engineering plant and mechanical equipment, preferably with engineering knowledge or background. Candidates should not be over 40 years of age and with good educational standard.
(B) **ASSISTANT BUYER** to assist in purchasing engineering materials and equipment under supervision. Candidates should not be over 30 years of age with good educational standard essential.
These are career appointments with good prospects and pension rights. Salary according to age and experience.
Applications to STAFF DEPARTMENT, "SHELL" REFINING & MARKETING CO., LTD., SHELL COURT, WHITE KENNETT STREET, LONDON, E.1. L 519

GRADUATE ENGINEER (MECHANICAL OR ELECTRICAL) with sound practical background and several years' experience as an Industrial Engineer (Consultant or otherwise) required by a large Company in the Electrical Industry with headquarters in South Lancs. Age preferably 30/35. An attractive and responsible post suitably remunerated.—BOX L 520, Offices of ENGINEERING.

MECHANICAL DRAUGHTSMEN urgently required by Major Oil Company for service in MIDDLE EAST OILFIELDS, age not over 40 years. Should be capable of executing layout drawings for boilers and auxiliaries, diesel pumping installations and of producing detailed drawings and Bills of Materials for works in connection with water storage, pumping and distribution, air conditioning, structural steelwork and simple industrial buildings. Should also be capable of making flow calculation for steam and water. Two years' tour and salary not less than £2,300 per annum.—Write giving age, brief details of career, etc., and asking for Application Form to BOX EG.186, c/o 191, GRESHAM HOUSE, E.C.2. L 523

EXPERIENCED PLANNING ENGINEERS required for production methods on medium I.C. engine components and fuel injection equipment. Pleasant working conditions, generous salary. Attractive Pension Scheme and Comprehensive Welfare Facilities.
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DAVY AND UNITED ROLL FOUNDRY LIMITED require a
GENERAL MANAGER to take charge of their Rolls and Steel Castings Business at BILLINGHAM.
Those applying must have metallurgical experience in the founding of heavy steel castings and preferably knowledge of steel and iron roll manufacture. Managerial experience is essential. The post carries a high salary and pension.
Applications should be sent to the MANAGING DIRECTOR, DAVY AND UNITED ENGINEERING COMPANY, LIMITED, PARK IRON WORKS, SHEFFIELD, 4. L 489

CIVIL ENGINEERING DESIGNERS.

MERZ AND MCLELLAN require
(*a*) **A SECTION LEADER** and (*b*) **DESIGNERS** with about 5 years' experience of design and construction in their design office at Newcastle-upon-Tyne, for work in connection with the large variety of Civil Engineering Structures associated with big coal-fired and Atomic Power Stations for public electricity supply.
Applications by letter in the first instance, quoting reference SAR, should be sent to MERZ AND MCLELLAN, CARLIOL HOUSE, NEWCASTLE-UPON-TYNE, 1. L 393

WORKS ENGINEER required as Assistant Works Manager for spun concrete pipe works. Qualifications, good sound knowledge of machinery maintenance and mechanical engineering, organising ability and ability to control labour. Knowledge of plant layout and heavy duty machinery essential. Preference for an applicant under the age of 35. Works located in Leicestershire.—Please apply to: THE MANAGING DIRECTOR, JOHN ELLIS & SONS LTD., 21, NEW WALK, LEICESTER, STATING QUALIFICATIONS AND SALARY REQUIRED. L 437

INSTRUMENT ENGINEER.

COURTAULDS LIMITED require an Instrument Engineer for their Central Instrument Department in Coventry. Applicants must be familiar with modern instrumentation theory and practice and be experienced in the handling of Instrumentation schemes for the automatic control of chemical processes, from the flow sheet stage to final commissioning.
Qualifications desired are a degree in a branch of engineering or physics, but applicants will be considered who have the required experience and alternative qualifications.
Candidates should write for a detailed form of application to the DIRECTOR OF PERSONNEL, COURTAULDS LIMITED, 16 St. Martins-le-Grand, London, E.C.1, quoting reference number B.35. L 466

GRADUATE ENGINEERS FOR CONSTRUCTION

Applications are invited for the following position with Major Oil Company Middle East.
(1) **ENGINEERING ASSISTANT TO CONSTRUCTION SUPERINTENDENT (CIVIL OR MECHANICAL ENGINEER)** with over five years experience field engineer construction process plant, industrial and general building projects. Familiar field organisational problems and with good working knowledge general construction and equipment. Age 30-40. Commencing salary £1580 p.a. up according experience, etc.
(2) **FIELD ENGINEERS (4) (CIVIL OR MECHANICAL)** with over two years experience in either general building projects such as housing, public buildings and utility installations or in oil refinery or chemical process plant installation and utilities. Must be familiar with job planning, scheduling and general construction techniques. Age about 30. Commencing salary £1245 p.a.
In addition to salaries quoted, free air conditioned accommodation and adequate living allowance provided with medical attention, kit allowance, pension plan and paid home and local leaves.—Apply (quoting CON) to BOX G 647, Offices of ENGINEERING.

DESIGNER-DRAUGHTSMAN for Hydraulic and heavy mechanical engineering works. Experience in Hydraulics essential. Applicants should preferably be of H.N.C. standard with a sound engineering training.—Apply stating age, qualifications and experience to HENRY BERRY AND CO., LTD., CROYDON WORKS, LEEDS, 10. L 470

DRAUGHTSMAN required, preferably with experience in power transmission. Five-day week. Pension Scheme.—Apply in writing to the CHIEF DRAUGHTSMAN, THE WELLMAN BIBBY CO., LTD., PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1. L 598

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ENGINEER

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The candidate requires qualities of a high order, he will report direct to the Board and his starting salary will be £2500 per year. It is intended that the appointment should ultimately carry a seat on the board.
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Applicants should have experience in these or similar fields.
Pleasant working conditions. Generous salary commensurate with qualifications demanded. Attractive pension scheme. Comprehensive welfare facilities.
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AUTOMATIC CENTRE PUNCH
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will play their part
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Men: Minimum qualification National Certificate in Engineering but Higher National very desirable.

Women: This vacancy would be of interest to a young lady who has Advanced G.C.E. as a minimum qualification with an interest in mathematics and physics.

Candidates should write giving full particulars to the PERSONNEL DEPARTMENT, COURTAULDS LIMITED, 16 ST. MARTINS-LE-GRAND, LONDON E.C.1, quoting reference number B.34. L 467

STRUCTURAL ENGINEER required by London firm of Consultants to take charge of their steel design office. Candidates must have a comprehensive knowledge of all types of structural steelwork both designing and detailing and should preferably have had some works experience. Applicants should be Corporate Members of one of the senior professional Institutions or hold similar Degrees. The post is a permanent one and there is a Staff Pension Scheme.—Please reply in confidence to BOX NO. 389, GLOVERS ADVERTISING, LTD., 351, OXFORD STREET, W.1. G 643

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7 in. by 3½ in. by 18.28 lbs. per ft.
8 in. by 3 in. by 15.96 lbs. per ft.

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10 ft. 0 in. by 5 ft. 0 in. by ½ in. plate.
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Please quote quantities and prices in the first instance to BOX G 1, Offices of ENGINEERING.

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QUALIFIED DESIGN ENGINEERS. Mechanical and Process Engineering. Projects or items of equipment designed or detailed.—Apply BOX L 48, Offices of ENGINEERING.

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The third edition of our booklet 'Rails and Rail Accessories' is now available. Copies will be forwarded on request.

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COMPLETE SUB-STATION EQUIPMENT of fairly modern design, Owner having installed a larger Sub-Station, consisting of:—

3 Panel Truck type Switchboard.
One Incoming panel Airblast type.
Two Outgoing panels Airblast type.
Two 750-kVA Transformers.
Two medium voltage panels, one to each Transformer.

The above operating on 6000/6600/400/230 volts, 3-phase, 50-cycles.

The above equipment will be released on August, 1956, and was installed 1944.

Reply to THE CHIEF ENGINEER, BROTHERTON & COMPANY, LIMITED, CITY CHAMBERS, LEEDS, 1, for further particulars. L 544

Classified Advertisements continued on Page **118**

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Specialists in the design and construction of Steam-Raising Plant, utilising waste gases, in the Gas, Chemical and Ceramic Industries; also the Iron and Steel Industries. Heat-recovery from internal combustion engines and similar prime movers in Land and Marine Installations. A direct method of saving fuel.

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22,000 BABCOCK & WILCOX C.T.M. STEEL CASED WATER TUBE, 260 lb. with Superheater, Economiser by Green, Chaingrate Stoker. All mountings.
15,000 BABCOCK & WILCOX C.T.M. TYPE WATER TUBE, 180 lb. with Superheater, Economiser by Green. All mountings.
TWO—14,000 JOHN THOMPSON 4 DRUM WATER TUBE, 250 lb. with Senior Economiser. All mountings.
30 FT. BY 8 FT. 6 IN. LANCASHIRE BY YATES & THOM, 160 lb. All mountings.
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Tel.: CARDIFF 29246. K 913

B.C.S.

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Tel.: CARDIFF 29246. K 915

PEARSON
ELECTRO HYDRAULIC FLANGING PRESSES,
120 TO 500 TONS.
Robust all-welded construction incorporating the most modern developments.
T. B. PEARSON & SONS LIMITED,
WINCOMBLEE ROAD,
WALKER,
NEWCASTLE-UPON-TYNE, 6.
(Tel.: No. Wallsend 64081.) G 652

PENSOTTI 5ft. Motor Driven High Speed VERTICAL BORING MILLS
with taper turning and screw cutting attachment. Max. swing 62 in. dia. Rapid power traverses. 16 speeds from 4 to 145 r.p.m. Motor 28 h.p. Approx. weight 10 tons. 1951-2 machines in excellent condition.
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359, Euston Road, London, N.W.1.
EUSton 4481 G 610

B.C.S.

ONE—400 K.W. SULZER DIESEL GENERATING SET, 220/440 volts, D.C. complete with Auxiliaries, Spares, etc.
ONE—850 K.W. SULZER DIESEL ALTERNATOR SET, 400/440 volts, 3 phase, 50 cycles, 428 r.p.m., complete with Auxiliaries, etc.
ONE—325 K.W. PAXMAN/CROMPTON PARKINSON DIESEL ALTERNATOR SET, 400/440 volts, 3 phase, 50 cycles, 1000 r.p.m., complete with Auxiliaries and Spare Parts.
ONE—245 K.W. PAXMAN/B.T.H. DIESEL ALTERNATOR SET, 400 volts, 3 phase 50 cycles, 1000 r.p.m., complete with Auxiliaries and Switchboard.
ONE—90 K.W. GENERAL MOTORS/HOUCHIN DIESEL ALTERNATOR SET, 400/440 volts, 3 phase, 50 cycles, 1500 r.p.m., complete with all Auxiliaries and Switchboard.
ONE—55 K.W. McLAREN/BRUSH DIESEL ALTERNATOR SET, 400/440 volts, 3 phase, 50 cycles, 1000 r.p.m., complete with Auxiliaries and Switchboard.
ONE—40 K.W. SENTINEL/LEROY DIESEL ALTERNATOR SET, 400/230 volts, 3 phase, 50 cycles, 1500 r.p.m., complete with Auxiliaries and Spare Parts. New 1951.
TWO—20 K.W. HILL & CO./DELCO DIESEL GENERATING SETS, 120 volt D.C., 1450 r.p.m., complete with Auxiliaries.
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Tel.: CARDIFF 29246. K 912

WARD, HAGGAS & SMITH FACEPLATE LATHE. Manufactured 1947. Max. swing over bed 5 ft. 11 in., admits 3 ft. 6 in. b.c. Geared chuck 5 ft. dia. Front and rear compound slides, power feeds to both. A.G.H. 18 speeds 4—95 r.p.m. M.D. 20 h.p. 400/3/50.
H. BELL (MACHINE TOOLS) LTD.
WALTER STREET, LEEDS, 4.
Tel.: 63-7398. G 649

THREE LANCASHIRE BOILERS
30 ft. by 9 ft.; 200 lb. W.P.; built 1953; in unused condition; complete with Economiser; Low price for prompt clearance.
BOX L 370,
Offices of ENGINEERING.

Get your free copies of the O-Ring Handbook and the Pioneer Catalogue — two publications prepared specially for engineers and designers.

When Oil seals must be 100% perfect Specify PIONEER

Under the most rigid tests Pioneer Oil Seals have successfully sealed lubricants, chemicals and gases and have been completely effective against water, dirt or any foreign matter.

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soot blowing

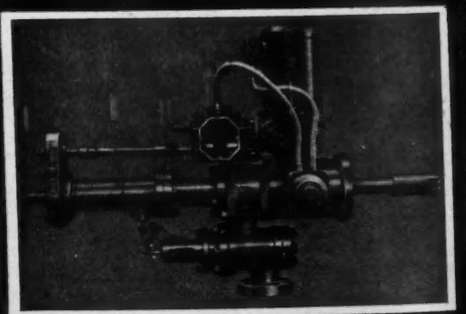
is a push-BUTTON job with the NEW CLYDE system

UNIFIED LECTRAMEK CONTROL SYSTEM

most efficient yet devised.

Considerable savings in initial cost and valuable boiler room space have been achieved by this new system of electrical control which works in conjunction with the Clyde Lectramek Soot Blower * - the original blower employing a uni-directional motor. Control is exercised from a small panel which indicates all essential information to the operator.

Further information is given in our publication No. CBL. 1954 which will be supplied on application.



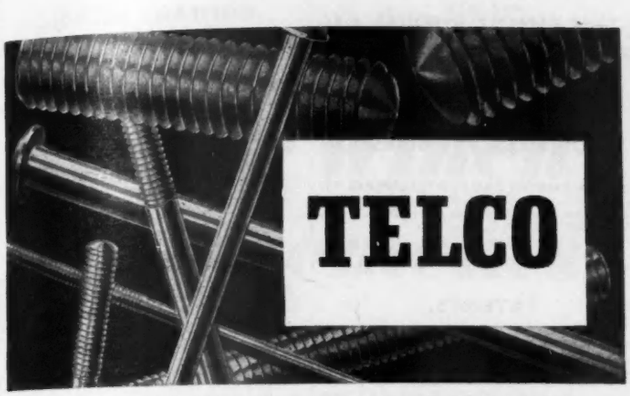
THE BLOWER. The complete operating cycle is in one motion and is driven through a compact mechanism by a non-reversing motor. When the operating shaft is rotated, the nozzle advances, the steam ports open and, at the same time, rocking motion is automatically transmitted to the nozzle. The uni-directional motor eliminates the bulky contactor gear used with reversing motors and reduces electrical maintenance by being of simpler and more rugged construction.
The reversing motion is achieved *mechanically* on all Lectramek blowers. A limit switch mounted on the gear box and connected to the starter regulates the stopping, starting and number of strokes.

AND THE CONTROL PANEL. Simple controls to operate the automatic sequence are grouped on this small unit which takes up little space on the main boiler control panel.

CLYDE

CLYDE BLOWERS LTD · CLYDEBANK · SCOTLAND · Tel: Clydebank 1576/7

** Over 5,000 blowers of this type in use all over the world.*



THREADED RODS AND HEADED RODS
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TELCO LTD. 3 Newman Street London W.1 MUSeum 5701/4

TWW

HYD. PUMPS.

HORIZONTAL THREE THROW BY BERRY, rams 2 in. dia. by 6 in. stroke; 2 tons p.s.i., press; approx. 13 g.p.m., 62 r.p.m. Gear wheel, pinion, etc.

HORIZONTAL THREE THROW BY HUGH SMITH, 1½ in. rams, 6 in. str.; 1 ton p.s.i.; 15 h.p. Slip Ring Motor, 400/3/50, 750 r.p.m., Starter.

THREE THROW HORIZONTAL HYDRAULIC PUMPS BY FIELDING & PLATT, cap. 10.5 g.p.m. at a working pressure of 2 tons p.s.i.; rams 1½ in. dia. by 3 in. stroke, all self-contained, and arranged for vee belt drive from 40 h.p. Brush Slip Ring Motor wound suitable for 400/440/3/50.

VERTICAL THREE THROW BY BERRY, rams 1⅞ in. dia. by 4 in. stroke, approx. 9 g.p.m., 3360 lb. p.s.i. 25 h.p. Slip Ring Motor. Ellison Starter.

THOS. W. WARD LTD.,
ALBION WORKS - - - SHEFFIELD
'Phone: 26311. - - - 'Grams: "Forward."
London:
BRETTENHAM HOUSE, STRAND, W.C.2.
'Phone: Temple Bar 1515 (12 lines).
Remember — Ward's might have it!
G 60

B.C.S.

TWO 14/20 H.P. RUSTON-HORNSBY DIESEL LOCOMOTIVES, 24 in. gauge in first-class condition.
3, CASTLE STREET, CARDIFF.
Tel.: CARDIFF 29246. K 914

Edwards

NEW BESCO DEEP THROATED COMBINED PUNCHING AND SHEARING MACHINE, 6/24. All-steel build. Capacity 6 tons. Punches ⅝ in. dia. by ½ in. mild steel. Shears up to ⅝ in. Other operations in proportion.

BESCO UNIVERSAL SWING BEAM FOLDING, BENDING AND BOX FORMING MACHINE. Capacity 49 in. by 14 s.w.g. Min. trunk formed round the beam 6¾ in. by 7½ in. high.

SIX NEW BESCO GEARED CIRCLE CUTTING MACHINES, Type F, Size No. 4. Motorised 420/3/50. Capacity ½ in. thick. Cuts circles 4¾ in. to 41 in. dia., strips ⅝ in. to 11 in. wide.

RHODES OPEN ENDED UNDERCRANK GUILLOTINE. All gauges. Capacity 49 in. by 18 s.w.g. Gap depth ½ in. Weight about 9 cwt.

TWO RATZER NO. 19 SIZE INCLINABLE PRESSES. Motorised 415/3/50. Pressure approx. 12 tons. Stroke 1½ in. Centre to back 5 in. Weight about 14 cwt.

BRITISH CLEARING NO. DH-80-55-36 DOUBLE SIDED DOUBLE ACTION HYDRAULIC PRESS. Steel plate frame. Motorised pump for 400/440/3/50. Complete with all hydraulic equipment. Punch pressure 80 tons. Blankholder pressure 55 tons. Max. pressure both slides 135 tons. Punch and blankholder strokes adjustable.

Photographs of the above are available.
MACHINE TOOLS, NEW AND USED,
Of Every Description. Attractive Prices.

F. J. EDWARDS LTD.,
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Telephone: EUSton 4681-3771.
And at
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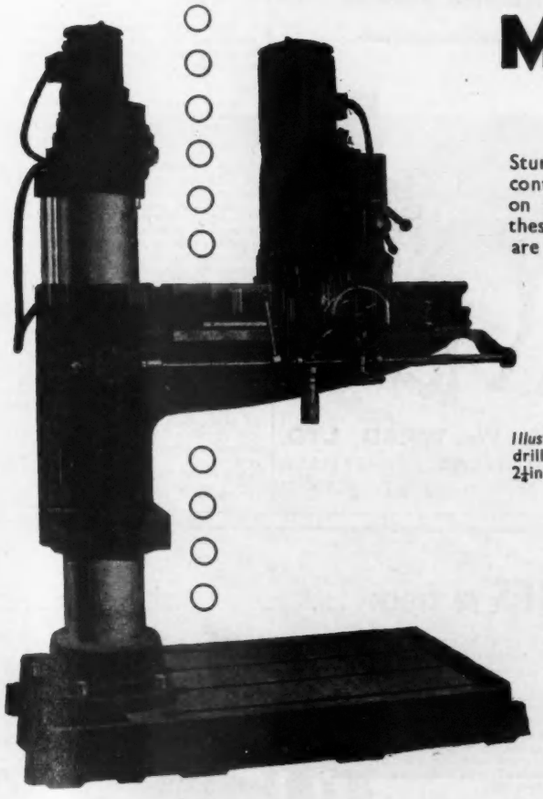
BIRMINGHAM, 3.
Telephone: Central 7606-7. G 552

TOWN
RADIAL DRILLING MACHINES



Sturdy, simple design, conveniently placed controls, maximum rates of production on the widest range of components—these are few of the reasons why they are used all over the world.

Illustrated: All-electric centralised control radial drilling, boring and tapping machine. Capacity 2¼in. dia. in steel.

FREDERICK TOWN & SONS LTD

HALIFAX · YORKS
ESTABLISHED 1903

T.3

SOAG

HIGH CLASS LATE TYPE
HORIZONTAL BORERS
AVAILABLE FROM STOCK!

KEARNS "S" TYPE, with collet type spindle, motor drive, with separate motor for table feeds, table size 22 in. by 16 in. long, table traverse 24 in., cross table traverse 12 in., vert. adjustment of spindle slide 12 in., 6 spindle speeds 80-1000 r.p.m.

KEARNS NO. 1 STANDARD TYPE, motor drive, facing head only, max. facing cap. 20 in., sliding table 33 in. by 24 in., revolving top table 24 in. by 24 in. max. distance facing head to outer stay 4 ft. 24 speeds 4-300 r.p.m.

KEARNS NO. 2 PATENT TYPE, motor drive, with traversing spindle and continuous automatic facing head, main table with detachable quartering table, vernier scales, outer boring stay, spindle dia. 3 in., facing capacity 30 in., main table 48 in. by 30 in., auxiliary top table 36 in. by 36 in., 24 spindle speeds, 3·1-250 r.p.m., h.p. of motor 5.

PEARN-RICHARDS NO. 4 STANDARD TYPE, motor drive, facing head only, max. facing capacity 48 in., sliding table 60 in. by 36 in., revolving top table 36 in. by 36 in., max. distance facing head to outer stay 7 ft. 7 in., 32 speeds 1·5-160 r.p.m.

RICHARDS "PRT 2" Motor drive, continuous feed facing head, power feeds and rapid power traverse in all directions, spindle dia. 3 in., facing capacity 30 in., max. traverse of spindle 48 in., main table 48 in. by 30 in., revolving top table 36 in. by 36 in., 32 spindle speeds 3·5-300 r.p.m.

CINCINNATI GILBERT, motor drive, power feeds and rapid power traverse in all directions, spindle dia. 3½ in., traverse of spindle 30 in., table working surface 60 in. by 48 in., 24 spindle speeds, 19-1070 r.p.m.

SCHARMANN HBSF3, motor drive, facing head, power feeds and rapid power motion to table and spindle, screwcutting and verniers, dia. of spindle 4 in., travel of spindle 31½ in., facing cap 39⅜ in., boring capacity 19⅝ in., working surface of table 47½ in. by 55½ in., max. distance spindle nose to outer stay 102⅜ in., 24 spindle speeds, 4·7-960 r.p.m., h.p. of motor 10.

NILES WV9 FLOOR TYPE HORIZONTAL BORER, flanged motor drive, spindle dia. 3½ in., facing head dia. 24½ in., travel of spindle 31½ in., travel of column 4 ft. 4 in., max./min. distance baseplate to spindle 60 in./18 in., 16 speeds 3-350 r.p.m.

For full particulars on any of the above write to:

SOAG MACHINE TOOLS LIMITED,
JUXON STREET, LONDON, S.E.11.
'Phone: RELiance 3513.
'Grams: Sotoolsag London S.E.11. G 230

Classified Advertisements continued on Page 120

FOR SALE.

OFFERED.

STEEL STORAGE BUILDINGS, HANGARS, GO-DOWNS, TROPICAL SHEDS, FACTORIES, ETC.—Write BELLMAN HANGARS, LTD., HOBART HOUSE, S.W.1. G 648

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M.S. CHEQUER PLATES
(Unused Stock, Rusty).
¼ in. over chequer.
8 in. by 4 in., 6 in. by 3 in., 6 in. by 2.5 in.
100 Tons available.
Minimum 2-ton Lots.
MADEN & McKEE LTD., 317, PRESCOT ROAD, LIVERPOOL, 13. L 469

FOR SALE.

M.S. ANGLES
(Unused Stock, Rusty.)
1¾ in. by 1¾ in. by 8 ft.
Large quantity available.
Minimum 2 Ton Lots.
MADEN & McKEE LTD., 317 PRESCOT ROAD, LIVERPOOL, 13. L 470

FOR SALE.

MODERN SINGLE STOREY FACTORY of 3000 sq. ft. in good, easy accessible position at Isleworth. Available immediate occupation £9000 Freehold.—Full particulars from NORMAN, SALTER & CO., 245, THE BROADWAY, SOUTHALL 3648. L 542

SURPLUS TO REQUIREMENTS—quantity of Oil Valves and Pipe Fittings, unused. Detailed lists on application to BOX ZK. 119, DEACON'S ADVERTISING, 36, LEADENHALL STREET, LONDON, E.C.3. L 559

FOR SALE.

7½ TONS CAPACITY OVERHEAD ELECTRIC CRANE by Higginbottom, Manchester, reconditioned. 27 ft. 9 in. Span. 3 motor type. 460 Volts D.C.—BOX L 564, Offices of ENGINEERING.

BUSINESS PREMISES.

LIGHT INDUSTRY FACTORY, 10,000 SQ. FT. East London outskirts, 1 floor, ample power, low ground Rent, Long Lease for sale.—BOX L 568, Offices of ENGINEERING.

PATENTS.

THE PROPRIETORS OF BRITISH PATENT NO. 687003 dated the 27th February, 1950, relating to "A PROCESS AND A POWER HAMMER FOR SWAGING STEEL" are desirous of entering into an arrangement by way of a Licence or otherwise on reasonable terms for the purpose of exploiting the above Patent and ensuring its practical working in Great Britain.

All enquiries to be addressed to:—
HERON ROGERS & COMPANY,
BRIDGE HOUSE,
181, QUEEN VICTORIA STREET,
LONDON, E.C.4. L 487

FOR HIRE.

LATTICE STEEL ERECTION MASTS (light and heavy) 30 ft. to 150 ft. high, for immediate hire.—BELLMAN'S, 21, Hobart House, Grosvenor Place, S.W.1. G 72

MISCELLANEOUS.

FOR THE UNUSUAL IN Technical Glass.—JENCONS (SCIENTIFIC), LTD., MARK ROAD, HEMEL HEMPSTEAD. Boxmoor 4641. L 26

COMPANY MEETING.

CROFTS ENGINEERS (HOLDINGS)

GRATIFYING TRADING RESULTS

The eighth annual general meeting of Crofts Engineers (Holdings) Ltd. was held on May 4 at Bradford, Sir Arthur Croft (Chairman) presiding.

The following are extracts from his circulated statement:

It is with great pleasure I present to you the Accounts for the year ended 31st December, 1955. We are again showing increased profits; but on this occasion these include the results of a full year's working of the whole of our Group of Companies, including the two Companies acquired during the previous year—Carter Gears Limited and J. Parkinson & Son (Shipley) Limited, and the substantial increase in profits is due in the main to this fact. Extensions and alterations have prevented us from reaching the production anticipated; all the same the results are very gratifying.

The Trading Profit, before providing for Taxation is £861,173; against £706,716 for 1954. Tax takes £415,332 leaving a net profit of the Group of £445,841 (against £356,476 for 1954).

During 1955 the capital was twice increased by the capitalisation of Reserves; the first occasion being in the proportion of one new share for every two Ordinary Shares held on the 7th June, 1955, which amounted to £400,000; and a second issue on the 22nd December, 1955, of one new share for every three shares held resulted in the further capitalisation of £500,000. In addition, an issue of new capital was made to Ordinary Shareholders in the form of a "Rights" Offer. Almost 100 per cent. of the new shares were taken up by them.

An Interim Dividend of 7½ per cent., less income tax, on the Ordinary Share Capital of £800,000 was paid in June, 1955, absorbing £34,500.

The Directors propose that a Final Dividend of 7½ per cent. should be paid on the £2,000,000 Ordinary Share Capital. The total distribution for the year on the Ordinary Shares is therefore £120,750, compared with £99,000 for 1954.

The Directors have given very serious consideration to the rate of Final Dividend proposed, and they feel that in future the Group should be able to finance its continued development out of its own resources. For this reason they have decided not to recommend an increase in the dividend rate, but to maintain the effective rate paid for the previous year—which in itself was an increase on the year 1953.

In my statement last year I informed you of the acquisition of J. Parkinson & Son (Shipley) Limited and Carter Gears Limited. Both Companies have installed additional plant during the year, also Parkinsons have put up Works extensions which are almost completed—it is expected that by the end of 1956 this Company will be well on the way to full production on its increased capacity.

The Fixed Assets of the Group clearly indicate the rapid growth of your Company. The net increase in these assets during the year is £303,000, and this reflects the continued policy of installing modern machines and equipment in the operating subsidiary companies. There are commitments outstanding at 31st December, 1955, for capital expenditure amounting to £218,000.

PROSPECTS.

The future prosperity of the Group depends on trade and demand. All our Companies are in a position to deal with increased business, and, as stated last year, although competition is keener, we feel that due to the added strength and greater efficiency being obtained we are in an even better position to secure our share of any business available.

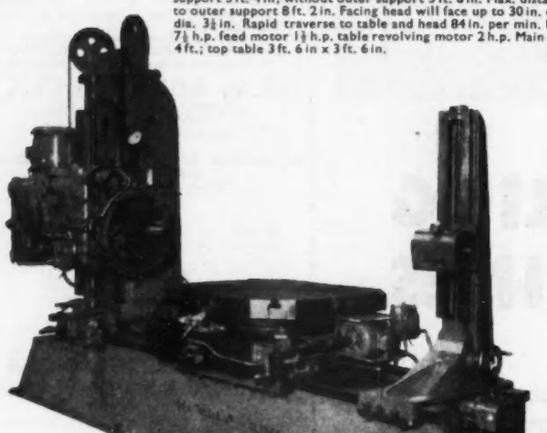
A general expansion in trade had taken place in all areas, both on Power Transmission equipment and Machine Tools, and our Canadian and South African Companies continue to show satisfactory progress.

The report was adopted. L 567

For Immediate Delivery

TULLIS Horizontal Surfacing, Boring, Milling & Drilling Machine

Electrical equipment 400/3/50; longitudinal travel of table with outer support 3 ft. 4 in; without outer support 5 ft. 6 in. Max. distance spindle to outer support 8 ft. 2 in. Facing head will face up to 30 in. dia. Spindle dia. 3½ in. Rapid traverse to table and head 84 in. per min. Main motor 7½ h.p. feed motor 1½ h.p. table revolving motor 2 h.p. Main table 3 ft. x 4 ft.; top table 3 ft. 6 in x 3 ft. 6 in.



One of the large number of new and secondhand machines which can be seen under ideal conditions at our modern Machinery Centre at Islington Park Street, London, N.1, near Highbury Corner.

F. J. EDWARDS LIMITED

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Telephone: EUSton 4681 (7 lines), 3771 (4 lines) Telegrams: Bescotools Norwest London

LANSDOWNE HOUSE, 41 WATER STREET, BIRMINGHAM, 3
Telephone: CENtral 7606-7 Telegrams: Bescotools Birmingham 3
G653

THOS. W. WARD LTD.
ALBION WORKS, SHEFFIELD
G 556

SOAG REBUILT GEAR MAKING MACHINES IN STOCK....

SHAPERS

Drummond-Maxicut No. 3 Heavy Duty Gear Shaper. Motor drive. Max. internal and external pitch dia. 18in., max. face width 5in., max. spur D.P. ¼in., max. helix angle for helical gears 36 deg., min. cutter dia. 4in.

Fellows No. 7I. Motor drive, for external and internal spur gears only. Max. ext./int. pitch dia. 7in./5½in., max. ext. face width 1½in., max. int. face width ¾in.-1in., max. ext. D.P. 6, max. int. D.P. 6/8 max. cutter dia. 3in.

Fellows No. 61A. Motor drive, for external and internal spur gears. Max. ext. and int. pitch dia. 18in., max. ext. face width 5in., max. spur D.P. 3/4, cutter dia. 3in. or 4in.; 8 speeds, 50-300 strokes/min.

HOBBERS

Pfauter R3 Gear Hobber. Motor drive through 6-speed gearbox, with differential max. gear, dia. 59in., max. face width 20in., max. D.P. 1¼.

Gould & Eberhardt Model 8H Gear Hobber, Motor drive, for spurs, splines, sprockets and worm wheels, max. dia. 6in., table dia. 10in., face capacity spur gears 12in., 4 D.P., 10 hob speeds, 48-200 r.p.m.

Klingelnberg Palloid Bevel Gear Hobber, Model AFK201. Motor drive, for pinions and gears. Max. dia. of bevels admitted (to be mounted at 90 deg.), ratio 1: 5 and over, pinion 4¼in., gear 21¼in.; up to ratio 1: 2, pinion and gear 15¾in. each; min. dia. of bevels as above, ratio 1: 5 and over, pinion 1¼in. gear 5¼in., up to ratio 1: 1 pinion and gear 4in. each; max. D.P. on Palloid spiral teeth 3.63.

Adams No. 5 Horizontal Gear Hobber and Thread Miller. Height of centres 9in., max. dist. between centres 48in., max. cutter dia. 6in., 8 hob speeds, 63-315 r.p.m.

PLANERS

Bilgram 6in. Straight Bevel Gear Planer. Motor drive. Single tool type, max. pitch dia. 7¼in. (ratio 1: 2), range of pitch angular adjustments 9 deg. to 85 deg., largest apex distance 7¼in., longest face 3in., coarsest pitch 3½ D.P.

Sunderland 5B, late type. Motor drive machine, for spur and spiral gears. Max. spur gear dia. 24in., max. face width 4in., max. D.P. 5, max. spiral gear combination 60 deg., ¼in. normal pitch, 2¼in. face width, max. dist. arbor end to outer support 16¼in.

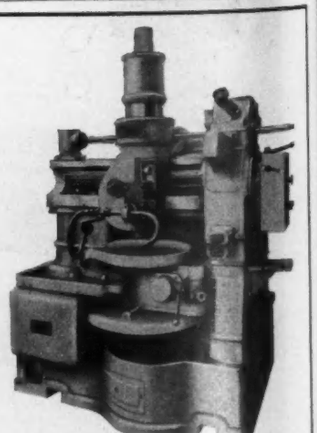
GRINDER

Pratt & Whitney 9in. Hydraulic Spur Gear Grinder. Motor drive. Max. dia. 10¼in., minimum pitch dia. 1in., face width 6in., max./min., diametral pitch 3in./16in.

Full details of any of the above gladly sent on request.

SOAG MACHINE TOOLS LTD., Juxon Street, London, S.E.11

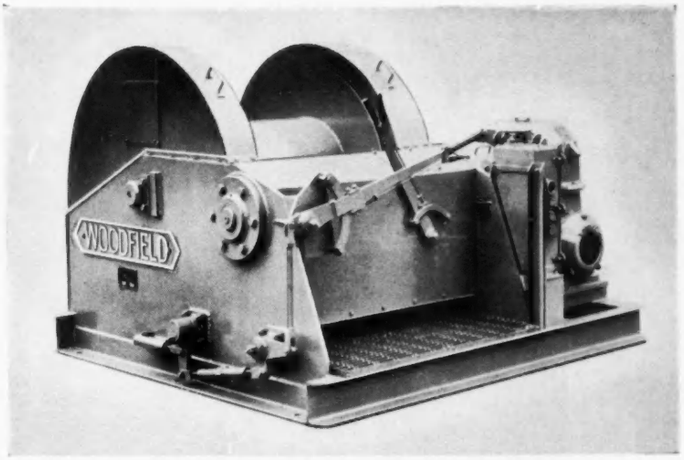
Phone: RELiance 3373. Telegrams: Sotoolsag London S.E.11

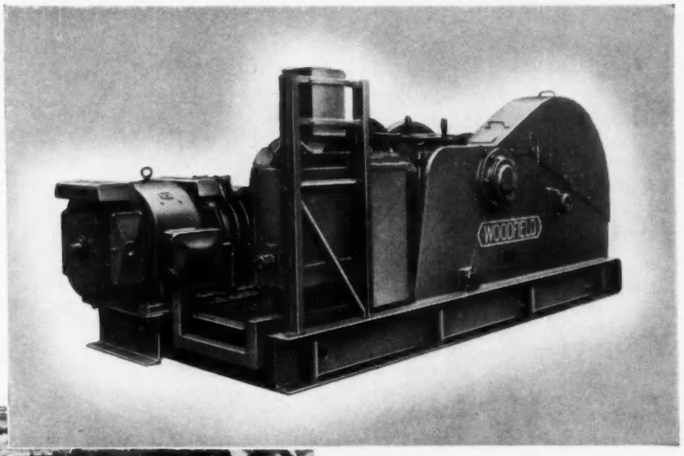


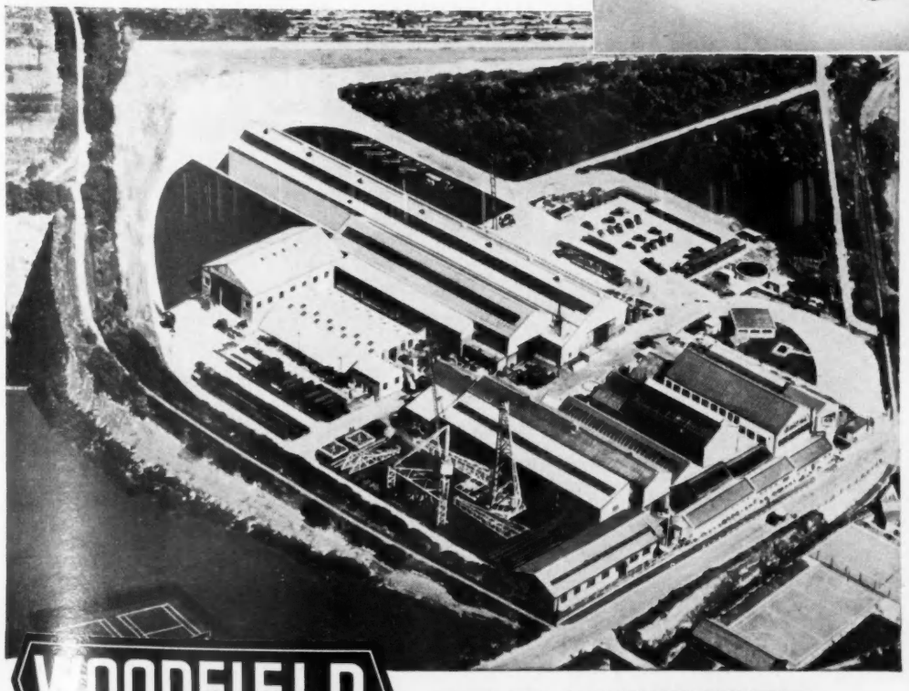
FELLOWS 61A G229

LONDON: HARRISON & SONS, LTD., by Appointment to Her Majesty The Queen, Printers, London, Hayes (Middx.), and High Wycombe, and Published by ENGINEERING Ltd., Proprietors of ENGINEERING, at 35 & 36, Bedford St., Strand, London, W.C.2.

...Your Winch requirements can be met by WOODFIELD continuous Development in this field







Top illustration:
Woodfield Anchor Winch for drilling barge, as supplied to The Shell Petroleum Company Ltd.

Lower illustration:
One of four Woodfield 30-ton electrically driven Winches for The National Coal Board off-shore drilling pontoon.

Left:
View of Rochester Plant covering 22 Acres, with Sports Ground on left.

***Woodfield manufacture :*— Oilfield Drilling and Servicing Equipment, Pipe Line Fittings, Hose Handling Equipment, Contractors' Plant including Pile Driving Equipment, Jig and Press Tools.**

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Incorporating KEMWORTHY JIG & PRESS TOOL COMPANY · LONDON

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this working exhibit on
STAND N°84
at the
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May 9th-19th
at Earls Court
make BIRTLEY your rendezvous
and see the Birtley
TROUGHED BELT CONVEYOR and
BLANKET CONVEYOR working
in association with PRIMARY and
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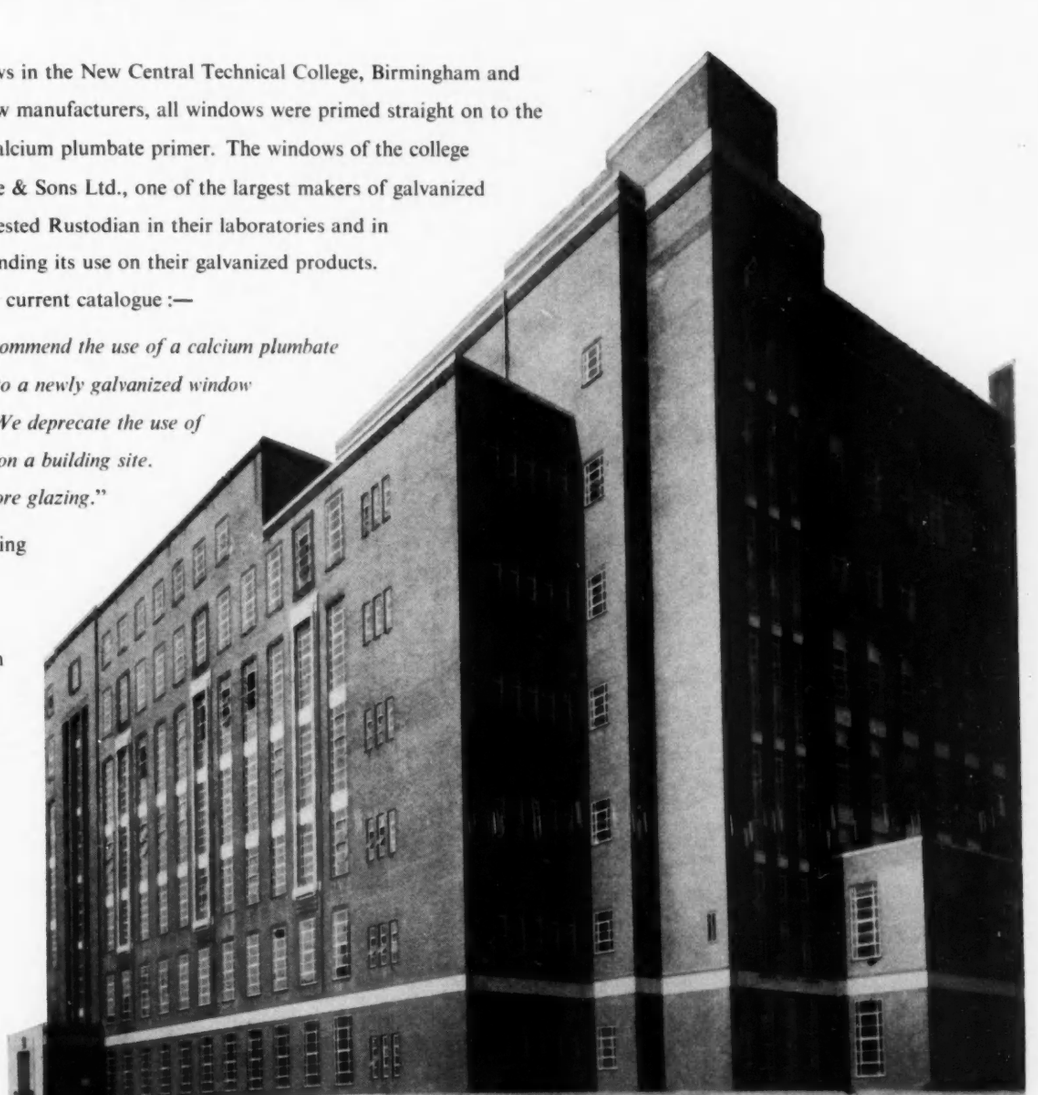
RUSTODIAN ON NEW GALVANIZING

THE primer for metal windows

There are over 500 galvanized windows in the New Central Technical College, Birmingham and on the recommendation of the window manufacturers, all windows were primed straight on to the new galvanizing with Rustodian—a calcium plumbate primer. The windows of the college were supplied by Messrs. Henry Hope & Sons Ltd., one of the largest makers of galvanized window frames in the country, who tested Rustodian in their laboratories and in the field for 3½ years before recommending its use on their galvanized products. This is what they recommend in their current catalogue :—

"PAINTING. *As a priming coat we recommend the use of a calcium plumbate primer. This paint will adhere firmly to a newly galvanized window without any prior etching treatment. We deprecate the use of mordant solutions applied to windows on a building site. It is advisable to apply the primer before glazing.*"

More and more architects are specifying this primer for the metal windows of such buildings because of their confidence in its exceptional adhesion and rust inhibiting properties. Rustodian is available in six colours and is supplied in the usual trade containers up to 5 gallon drums.



ASSOCIATED LEAD *

Associated Lead Manufacturers Limited is a single Company which specialises in the manufacture of Lead Pigments and Lead Paints.

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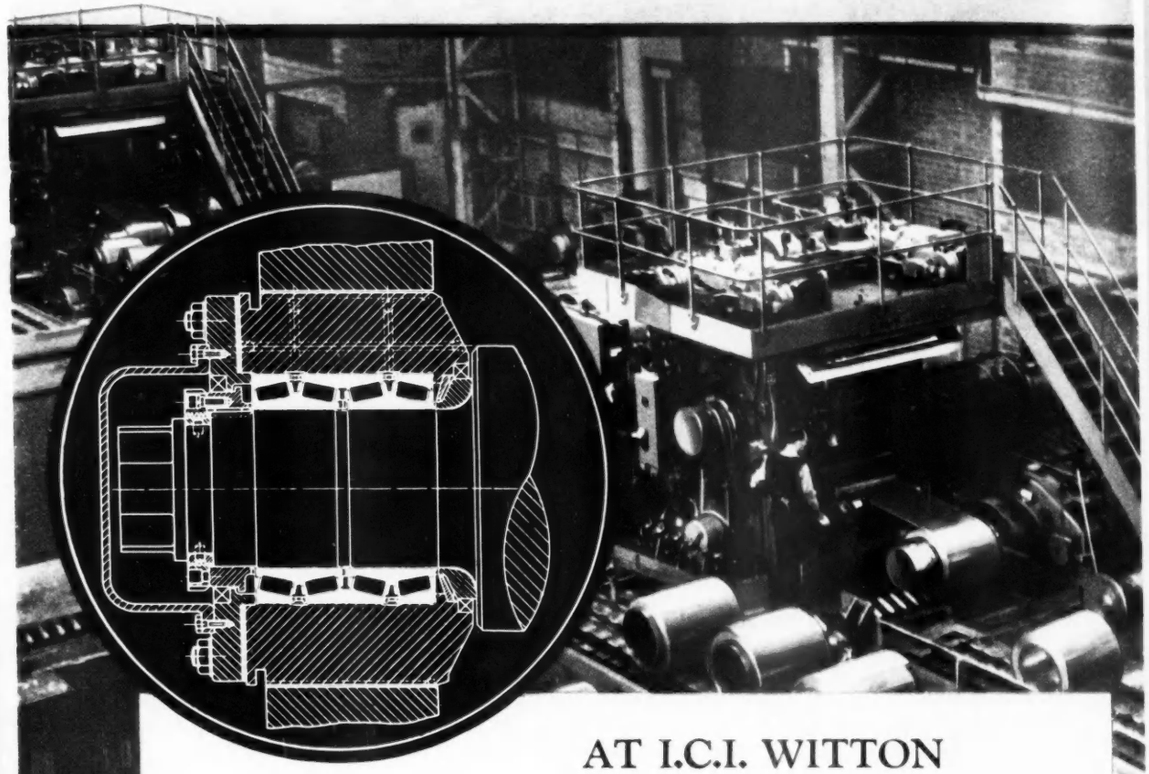
ENGINEERING

An Illustrated Weekly Journal

STRIP MILLS FOR COPPER AND BRASS



AT I.C.I. WITTON

The illustration shows two 6½″/8½″ and 28″, by 32″, 4-high mills, for rolling copper and brass strip at speeds up to 1,000 ft. per min.

These, together with a 15″ and 32″ by 36″ 4-high intermediate mill, were recently commissioned at the Witton factory of I.C.I. Metals Division.

All three mills were supplied by Davy and United Engineering Company Limited, and all of them have Timken back-up and work roll bearings.

The line drawing shows the 4-row balanced-proportion bearings, as used on the back-up rolls.

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